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Performance Comparison of Tropospheric Propagation Models: Ray-Trace Analysis Results Using Worldwide Tropospheric Databases

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The report describes the performance of three databases and tropospheric models and covers the analysis results for several selected refractivity and range/angle error models, three empirical databases of global climatological, and meteorological data. Most performance comparisons are conducted through time delay, range error, and angle of error for areas of interests on different climatology to induce reasonable conclusions. A modified exponential model is proposed as the best performer among the many models examined based on the level of accuracy, minimum level of the databases including surface weather data, and the real-time data applicability.

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PERFORMANCE COMPARISON OF TROPOSPHERICPROPAGATION MODELS: RAY-TRACE ANALYSIS RESULTS USING WORLDWIDE TROPOSPHERIC DATABASES

1. INTRODUCTION

The physics of atmospheric propagation in communication systems is affected by ever-changing meteorological conditions in the atmosphere and complex boundary conditions on the ground. Whereas forecasting meteorological conditions in small areas is by itself difficult, if not impossible, prediction of propagation adds another dimension of difficulty. This is understandable because the boundary conditions of the problem are complex and constantly changing, and the solution process in itself is not simple whether one uses a wave-optics or a geometrical-optics approach. A great deal of interest has been focused recently in the areas of signature analysis, classification, and modeling of airborne/spaceborne synthetic aperture radar (SAR) data, topography, telemetry/command data, tracking, and accurate determination of aircraft or spacecraft position and orbit parameters as well as geophysical parameters. An important requirement within most of those application areas is the geometric and radiometric calibrations of airborne or spaceborne data. In airborne and spaceborne communication systems, the dynamic properties of the aircraft (or spacecraft) and the atmospheric turbulence can produce large motion errors, which introduce additional geometric and radiometric distortions in the data. Errors from tropospheric effects generally have been neglected during the calibration process of those spaceborne data since other sources of errors (i.e., Doppler shifts, ephemeris, geodetic systems, spacecraft motion, etc.) have produced much larger errors. The performance of low-angle microwave propagation over the Earth's surface is the mode of tropospheric refraction that affects most types of radar and navigational systems like the microwave landing systems used at airports, as well as line of sight (LOS) and mobile radios.

Tropospheric refraction produces two main effects on radio waves-—angular bending and time delay. The angular bending is due primarily to the change of the index of refraction with the height of the atmosphere. The time delay occurs primarily because the index of refraction is greater than unity, thus slowing the speed of the radio wave, and to a lesser extent, because of the lengthening of the path by angular bending. The correction measures of these two tropospheric propagation problems have been proposed based on model-based or empirical measurements in terms of frequencies and climatic regions over the years [1-6] to reduce propagation errors in telecommunication systems links. Many tropospheric models have been proposed since the early 1950s. Only five models are selected in this study (Hopfield, Goad, Blake, exponential, and Cains with Case 1) because other models are not directly related to this project or not good enough to generate an acceptable range of performance. Little information exists on Earth-space propagation at lower elevation angles ($\leq 5°$). However, important details relating to the properties of the received signal are generally less certain. These details might include signal amplitude, delay times between different paths, and individual angles of arrival under multipath conditions. Meteorological uncertainties severely limit the usefulness of models of existing microwave propagation passing through low atmosphere specifically in the presence of precipitation and in the low elevation

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angles. Many propagation problems on the LOS links arise from the occurrence of anomalous departures from the normal value in the vertical gradient of the refractive. This value itself will vary slowly with season, time of day, location, and the standard gradient in refractivity often being quoted as –40 N-unit/km, corresponding to a 4/3 Earth [6]. The propagation effects that are prevalent when radio waves traverse the atmosphere manifest themselves as refractive bending, time delays, Doppler errors, rotation of the plane of polarization (Faraday effect), dispersion effects, and attenuation. The atmospheric radio refraction effects in the tropospheric region cause an extra time delay in transmission of the signal and an increase in the elevation angle measured by the antenna system. In other words, there are two types of errors: errors in measuring distance by means of timing the transit of radio signals between two points (known as range errors) and errors in estimating the elevation angle of a target by means of measuring the angle-of-arrival of radio signals from the target or spacecraft (known as elevation angle errors) [7]. The emphasis here is concentrated on the physical phenomena in the atmosphere using empirical data rather than on building models or analyses based on models developed.

New systems that operate at low elevation angles require improved accuracy in range errors and angle-of-arrival errors. An approach for obtaining more accurate angle and range error corrections is to use calibration sources such as the limb of the Sun, radio sources, or satellites for angle error cases. Neither radio sources nor satellites are suitable for range error calibration since radio sources are collected passively, and the true range of a satellite is not generally known to a sufficient degree of accuracy to be of value. In the formulation of these problems, an idealized model of a time independent, spherically stratified nonionized atmosphere with an index of refraction that monotonically decreases with increasing altitude is adopted for a newly proposed model. The new tropospheric model is proposed here with five other potential tropospheric propagation models [1-6] developed over the last 3 decades; they are presented for comparison purposes to correct lower angle propagation errors such as time delays or range and angle errors. Important details relating to the properties of the received signals are generally less certain; such details might be signal amplitude, delay times between different paths, and individual angles of arrival under multipath conditions.

There are many variables that influence Earth-space propagation. They fit into the broad categories of frequency, space, and time. Propagation effects depend on all these variables and are quantified through measurements or modeling. In some cases, measured values can be applied directly. In other words, data might be available for the particular frequency, elevation angle, and climate zone for a proposed system. More commonly, measurements are used in combination with theoretical calculations from fundamental propagation physics to develop models that explain the variations and that can be evaluated for specific situations. In fact, models usually are used to predict average behavior while measurements over some periods reveal the year-to-year, season-to-season, or day-to-day variability. In order to be comprehensive, this report covers the analysis results for both selected leading models and three measured worldwide climatological and diurnal meteorological databases. A brief overview of database characteristics that will be applied in this study is presented in Section 2. Each leading model with a new proposal is introduced in Section 3 with details of mathematical and physical principles. Results of this study are described in Section 4. Conclusions and recommendations are in Section 5, followed by references and acknowledgments. Finally, figures and tables of analysis results are included in the Appendixes.

2. DATABASE CHARACTERISTICS

Databases make use of raw information provided by the Air Force, Navy, and National Oceanic and Atmospheric Administration (NOAA). Software developed on the project takes these raw data and formats them into a standard Naval Research Laboratory (NRL) format. The software makes use of tropospheric models that permit the addition of tropospheric refractivity, grid number, and related

statistics with height information. The wind speed, wind direction, and precipitation can be added upon request if the customer requires this additional information. The resulting database of refractivity and related statistics is created using either EMPRESS database software or FORTRAN and C on Sun SparcStations. All refractivity and related statistical data are stored in a readable text ASCII format and are also available in Tar and VAX formats. These 17 variable outputs are available in hard copy or as soft copy on 8-mm magnetic tapes.

2.1. Data Sources

This task has produced six databases using data from the following three government agencies; the Air Force, the Navy, and NOAA. Results obtained with these data will be available to government agencies and laboratories for further research and modifications. The six data sources currently supported are the following:

1. European Center for Medium-Range Weather Forecast (ECMWF) from the U.S. Air Force Environmental Technical Applications Center (ETAC) at Scott Air Force Base, Illinois.
   - includes data averaged monthly over the years 1981 to 1991 with $2.5^\circ \times 2.5^\circ$ grid;
   - 17-layered data by geopotential height and pressure levels from 10 to 1000 mbar;
   - other data elements include latitude, longitude, temperature, dew point, air density, and number of observations used to obtain mean and standard deviation values.

2. Asheville Marine data from the National Climatology Data Center (NCDC), NOAA.
   - includes upper-air diurnal data over the period of January 1980 to June 1993 with $2.5° \times 2.5°$ grid;
   - 40-layered data by geopotential height and predefined pressure from 10 to 1000 mbar over the coastal lines and oceans around the world;
   - other data elements include temperature, dew point, height, number of levels, latitude, longitude, date, and time.

3. Fleet Numerical Meteorological and Oceanographic Center (FNMOC) data from the Naval Meteorology and Oceanography Command in Monterey, California.
   - includes mean sea-level and upper air data every 12 h from January 1994 to February 1996 with $2.5° \times 2.5°$ grid around the world;
   - 17-layered data by geopotential height and predefined pressure level from 200 to 1000 mbar;
   - other data elements include air temperature, dew point, wind vector and speed, latitude, longitude date, and time with $2.5° \times 2.5°$ grid.

4. High-Resolution Analysis System (HIRAS) data from ETAC, Scott Air Force Base, Illinois
   - includes the monthly and 6 hourly averaged climatology data over the period of July 1988 to June 30, 1994 with $2.5° \times 2.5°$ grid around the world;
   - 17-layered data by geopotential height and predefined pressure level from 10 to 1000 mbar;
   - other data elements include temperature, relative humidity, height, latitude, longitude, date, and time.

5. Medium-Range Forecast (MRF) data from NCDC, NOAA
   - includes 6 hourly diurnal meteorological data over the period of January1, 1991, to December 31, 1995, with $2.5° \times 2.5°$ grid around the world;
   - 13-layered data by geopotential height and predefined pressure level from 50 mbar (24 km from the surface in the air) to Earth surface;

- other data elements include air temperature, relative humidity, wind vector and speed, latitude, longitude, date, and time

6. Final Analysis (FNL) Data for MRF
   - includes 6 hourly diurnal meteorological data over the period of January 1, 1997, to present with $1.0° \times 1.0°$ grid around the world;
   - 14-layered data by geopotential height and predefined pressure level from 20 mbar (26.6 km from the surface in the air) to Earth's surface;
   - other data elements include temperature, relative humidity, total cloud cover, wind vector and speed, geopotential height and pressure vertical velocity.

2.2 Accessing Databases

Details of accessibility for each database are referred to in Ref. 8. HIRAS and MRF databases are not included in Ref. 1, and their configuration management is similar to others and will be provided upon request.

3. MODELING

A discussion of tropospheric effects on radio waves can be divided into two parts—the refractivity model and range or angle-of-arrival-error model. Many models involving refractivity or range and bending errors have been proposed during the last several decades. It is impossible to cover here all the models published thus far. Rather, this report concentrates on a few leading models on both refractivity and range or angle errors in order to present a feasible approach that is useful for system implementation in real-world applications, as pointed out in Section 1.

3.1 Refractivity Models

Since the introduction of refractivity N by Smith and Weintraub in 1953 [9] as

$$N = (77.6/T)[p + 4{,}810 * e/T], \tag{1}$$

(where T is the temperature in Kelvin, P the pressure in mbar, and e the water vapor pressure in mbar), scientists and engineers have proposed numerous refractivity profiles to understand the propagation path in the atmosphere for the compensation of range and angle error at low elevation angles. Angular bending is due primarily to the change in the index of refraction with the height of the atmosphere. Time delay occurs primarily because the index of refraction is greater than unity in the tropospheric region to the height of about 30 km from the ground, thus slowing the radio wave, and to a lesser extent, because of the lengthening of propagation path by angular bending. In general, refractive errors increase with decreasing elevation angle for a standard atmosphere.

3.1.1. Effective Earth Radius Model

The Earth radius model was formulated by Schelleng et al [10] and was first used for the LOS communications problems. It was shown that, by assuming that the Earth has a radius of about 4/3 that of the actual Earth, radio wave rays could be drawn as straight lines. It is evident that the 4/3 Earth atmosphere has about the correct slope in the first kilometer or two above the Earth's surface but decreases rapidly above that height. From an examination of many years of N-profile data for various climates, the observed refractivity distribution is more nearly an exponential function of height than a linear function of height as assumed by the 4/3 Earth atmosphere. One might expect that refractivity

decreases exponentially with height since the first term of Eq. (1) involving *p/T* comprises at least 70% of the total and is proportional to air density, a well-known exponential function of height. It appears that this success is due to the 4/3 Earth's model essentially being in agreement with the average N structure near the Earth's surface that largely controls the refraction of radio wave rays at small values of elevation angle common in tropospheric communication systems. Based on numerous studies, refractivity N may be represented by an exponential function of height of the form:

$$N(h) = N_s \exp\{-bh\}, \tag{2}$$

where N is the surface refractivity, b the constant, h the altitude from the surface in the altitude range of 1 to 9 km above the sea surface level. The effective Earth radius model works well for propagation paths at low altitudes where ray paths are within about 2 km of the Earth's surface but not for those at higher altitudes. Further details of Eq. (2) can be broken down into the region as

$$N(h) = N_s + (h - h_s)\,\Delta N \qquad \text{for } h_s \le h \le h_s + 1, \tag{3}$$

where $-\Delta N = 7.32 \exp\ \{0.00557\ N_s)$ and h_s is the surface height. (4)

Equations (3) and (4) are based on the effective Earth's radius concept in the first kilometer from the surface. In this atmosphere, N is assumed to decay linearly with height from the surface h_s to 1 km above the surface $h_s + 1$.

$$N(h) = N_1 \exp\ \{-c(h - h_s - 1)\}, \qquad \text{for } h_s + 1 \le h \le 9\ \text{km}, \tag{5}$$

where $$c = \{1/(8 - h_s)\}\ln(N_1/105), \tag{6}$$

and N_1 is the value of N at 1 km above the surface. Above the altitude of 9 km, where less than 10% of the total bending occurs, a single exponential decrease of N may be assumed. The coefficients in the exponential expression:

$$N(h) = 105 \exp\ \{-0.1424\ (h - 9)\}, \qquad \text{for } h \ge 9\ \text{km} \tag{7}$$

were derived by the Rocket Panel data [11].

The three-part model of the atmosphere expressed by Eqs. (3), (5), and (7) has the advantage of the effective Earth's radius model approach, particularly for such applications as point-to-point radio relaying over distances up to 100 miles where the radio energy is generally confined to the first kilometer and being in reasonably good agreement with the average N-structure of the atmosphere. Note that the 4/3 Earth model with its constant decay of 39.2 N units per kilometer would be a poor representation of the maximum profile, which decreases over 66 N-units in the first kilometer. This implies that the 4/3 Earth model closely represents the slope of the minimal N_s profile over the first kilometer but then decreases too rapidly with height.

3.1.2. Exponential Model [1, 12]

If it is supposed that the Earth's atmosphere consists entirely of isothermal ideal gas, the tropospheric refractivity profile is, as is well known, calculated from the state of the ideal gas equation. If the refractivity N_s at the height h_s is equal to

$$N(h) = N_s \exp\left\{-(gM/RT)(h - h_s)\right\}, \tag{8}$$

or simply

$$N(h) = N_s \exp\left\{-c_e(h - h_s)\right\}, \tag{9}$$

where g is the acceleration of gravity (9.80 m/s ^{2}), M the gram molecular weight of the air (29.0 g), R the gas constant (8.3144 J/mol-K), T the absolute temperature in Kelvin, and

$$c_e = \ln\left[N_s / N(1.0\ \text{km})\right] \text{ or } = \ln\left[N_s / (N_s + \Delta N)\right]. \tag{10}$$

These models of atmospheric refractivity (Eqs. (8) and (9)) are a close representation of the average refractivity structure within the first 3 km. Further, the single exponential model has the advantage of being an entire function and, therefore, is easily used in theoretical studies. The exponential reference atmosphere is in good agreement with the initial N distribution but tends to give systematically low values above ~3 km. Therefore, the exponential reference atmosphere does not appear to be as good a representation of the two observed profiles as the reference atmosphere, particularly above approximately 5 km.

3.1.3. Hopfield Model [2]

The actual atmosphere is not isothermal nor is its composition an ideal gas, and the state of water vapor in the atmosphere is different from the state of an ideal gas. Therefore, it is more practical to express the refractivity in the quartic term induced by the dry air or the water vapor separately as follows:

$$N(h) = N_d + N_w, \tag{11}$$

where N_d is the dry refractivity and N_w the wet refractivity represented by

$$N_d = k_d\,(h_{0d} - h)^4, \tag{12}$$

$$N_w = k_w\,(h_{0w} - h)^4, \tag{13}$$

with $k_d = 1/[h_{0d} - h_s]^4$, $k_w = 1/[h_{0w} - h]^4$, h_{0d} the dry height of the order of 40 km, and h_{0w} the wet height of the order of 12 km. Note that if the refractivity as a function of height is represented by an exponential, it is not integrable in closed form, where if it has the form as in Eqs. (11) through (13), it is integrable. The representation of the dry and wet terms of refractivity by quartic Eqs. (11) through (13) gave good agreement with range error and Doppler data above 6° elevation angles. Note that if monthly or weekly averages of the refractivity are used and the accuracy is not so important, this model is useful and practical.

3.1.4. Modified Exponential Model

It has been seen that the observed refractivity distribution is more nearly an exponential function of height than a linear function, as assumed by the effective Earth's model. The exponential decrease of the refractivity N with height is sufficiently regular as to permit a first approximation of average refractivity N structure from surface condition alone. Consider that

$$N(h) = N_s \exp(-h/H), \tag{14}$$

where H is a scale (or reference) height appropriate to the value of N at zero height N_s. Considering a scale height here, it is simply the height at which the value of $N(h)$ is $1/e$ of N_s under the assumption of Eq. (14), at which the height h is equal to the scale height H. The wet refractivity N_w is below 1.0 N-unit in comparison with the dry refractivity N_d with 100 N-units in the neighborhood of the selected value of a reference height H. The ratio of dry to wet refractivity is approximately 100 at the reference height H where the height from the surface is one-third of the total tropospheric region. The refractive phenomena of bending and time delay beyond this layer (reference height) will be limited since temperature and humidity do not change drastically to affect refractive bending in those extended areas such as tropopause, stratosphere, stratopause, free space, and ionosphere above 1 GHz. This coincides with the fact that most bending and refractive phenomena occurs within this region (beneath the reference height) from the surface of the Earth. This implies that the tropospheric effects on the ray bending can be approximated with the reference height without significant loss of any physical or atmospheric theory.

As it is well known, the atmospheric pressure tends to decrease exponentially in accordance with [13, 14]

$$P = P_0 \exp(-h/H), \tag{15}$$

where h is the height above a reference level where the pressure is P_0. It is noted that the scale height H, however, is not a constant as it is a function of temperature T, the average mass M of the molecules present, and the acceleration of gravity g as shown in the Eq. (8) by

$$H = kT/Mg, \tag{16}$$

where k is Boltzmann's constant. The rate of change of temperature with altitude in a dry atmosphere in an adiabatic state involving no input or loss of heat energy is given by

$$dT/dh = -9.8°\ \mathrm{C/km} \tag{17}$$

If the actual lapse rate of the atmosphere (rate of decrease of temperature with altitude) is 9.8° C/km, a parcel of air that is originally in equilibrium with its surroundings and which is then moved upwards or downwards will tend to remain in equilibrium at the same temperature as its surroundings. Then the parcel of air will not be subject to any restraining or accelerating force. Such a lapse rate of temperature is referred to as neutral. If the actual lapse rate of atmosphere is greater than 9.8° C/km, a rising parcel of air will tend to cool only at the adiabatic rate and is warmer than its surroundings. As a result, it will be lighter than the air around it and will be accelerated still further upwards.

In an inversion layer, temperature increases with altitude, and such a layer is highly stable. All vertical motions are strongly inhibited in an inversion layer, and pollution emitted below the layer tends to be confined below it. Also, if a source of water vapor exists below an inversion layer, it tends to be confined below the layer, with the result that large decreases in index of refraction may be encountered in the upward passage through an inversion layer. Thus, the occurrence of inversion layers has an important effect on low-elevation angle Earth-space communication paths. The decrease or change of the water vapor pressure e with height is generally variable but may be approximately exponential. Note also that the delay caused by water vapor is considerably smaller than that for dry air above 3 to 5 km from the surface, but total water vapor content along a path is variable and not predictable with high accuracy from the surface water vapor pressure or density. Therefore water vapor is responsible for a larger error or uncertainty in the range than in dry air at lower atmosphere.

This kind of exponential model is widely applicable and is dependable when reliable climatological or meteorological data on actual refractivity profiles are applied. In this report, a worldwide 2.5° × 2.5° grid accuracy is used. This model provides the accuracy of less than 1% of root-mean square (rms) error from the climatology or meteorology data in comparison with the accuracy of 20% to 30% of rms errors for the Hopfield and other models. Therefore, this model approach has been chosen here as the most reliable and accurate in comparison with other models for various conditions. The comparison and tested results are presented in Section 4 for both spatially, temporally, and geographically diverse environmental conditions.

3.1.5. Complex Refractivity Model [15, 16, 17]

With the current high interest in millimeter and submillimeter waves, there is a need for a reliable model to predict average loss and delay effects from easily obtained meteorological data. Such a model would find practical application through conversion of basic climatological variables (i.e., temperature T, barometric pressure P, relative humidity Q) into transfer characteristics of a radio path. In atmospheric turbulence, the fluctuations in T, P, and Q cause fluctuations in both the real and imaginary parts of the refractive index. Such fluctuations cause random refraction and absorption of electromagnetic waves passing through the medium. At visible and radio frequencies, the refractive index is a relatively simple function of T, P, and Q, and it is fairly easy to express the fluctuations of the refractive index in terms of the fluctuations of T, P, and Q, as shown in Eq. (1). However, for electromagnetic radiation at millimeter and submillimeter waves, the presence of absorption resonance causes both real and imaginary parts of the refractive index to depend on T, P, Q, and frequency in a more complicated manner. The complex refractivity N, expressed in terms of measurable quantities, provides that role. For air, N consists of three components:

$$N = N_0 + D(f) + jN''(f), \tag{18}$$

namely, frequency independent refractivity N_0 plus various spectra of refractive dispersion $D(f)$ and absorption $N''(f)$. The imaginary part of Eq. (18) is usually expressed as the specific power attenuation α, and the real part determines the phase delay β (with reference to vacuum). That is

$$\alpha = 0.1820\, fN''(f) \qquad \text{dB/km}, \tag{19a}$$

$$\beta = 0.02096\, f(N_0 + D) \qquad \text{rad/km}. \tag{19b}$$

Accordingly, the propagation constant Γ and the excess propagation delay time t are

$$\Gamma = -0.1151\,\alpha + j(2.096 * 10^4 f + \beta) \qquad 1/\text{km}, \tag{20a}$$

$$t = (\beta/2\pi f)*10^3 = 3.336\,(N_0 + D) \qquad \text{ps/km}. \tag{20b}$$

where ps denotes picosecond. Note also that water vapor refractivity is about 16 times more effective on a per-molecule basis than dry air in generating propagation phenomena such as time delay, ray bending, ducting, scintillation, etc. The absorption and dispersion spectra are formulated from the contributions of a continuum N''_c, and a liquid water extinction N''_w; i.e.,

$$N''(f) = \sum_I (SF'')_i + N''_c + N''_w \qquad \text{ppm} \tag{21}$$

and

$$D(f) = \sum_{I} (SF')_i \qquad \text{ppm}, \tag{22}$$

where SF'' is the line spectra of the absorption and SF' the refractive dispersion with strength S in units of kilohertz and shape factors F' and F'' in units of $(\text{GHz})^{-1}$. Since both Eqs. (21) and (22) require more elaboration, one can refer to Ref. 15 for further details of derivations and characteristics.

3.2. Range and Angle Error Models

Many models have been proposed to investigate the causes of the observed errors in range and angle-of-arrival errors and to determine the orbital elements of an artificial satellite. These models include the azimuth-elevation angle method, the radio interferometer method, and the laser ranging method. The radio wave propagation between a ground station and a spacecraft is subject to the bending of the propagation path and the decrease in the propagation velocity in the Earth's atmosphere. These effects cause systematic and random errors in the range, range rate, and the angle-of-arrival measurements. The errors caused in the ionosphere can be reduced to as small as desired by the use of shorter waves such as millimeter or centimeter waves, and the errors in the troposphere are also reduced to about an one-half or two-thirds if the proposed approach is adopted using an available climatology database.

There are different approaches used to compute range and range errors that consider refraction effects to improve range measurements by removing systematic bias. The range error is composed of three parts: the difference between the curved length of the propagation ray path R and the true slant range R_0, mainly due to the increase in time necessary to travel over the curved path R; timing errors in the detection system; and the discrepancy caused by the lowered velocity of propagation in a refractive medium. Propagation times for waves traveling between the ground station and a spacecraft are longer than the figures calculated for open space for two reasons:

1. The path does not follow a straight line. The consequent increase in path length is small and can be neglected except for angles of elevation below 5° to 10°.

2. The radio wave velocity is slightly lower than it would be in a vacuum, producing an apparent increase in the length of the path given by the relation:

$$\Delta R = \int_R (n-1)\, ds, \tag{23}$$

where s is the curved abscissa on the path, and R the distance of the spacecraft, which can be treated as infinite for the purpose of these calculations as atmospheric effects only influence the first few kilometers. As the real path does not deviate much from a straight line with the angle of elevation θ, as long as θ is greater than a few degrees, the range error can be approximated as:

$$\Delta R = \int_0 \left[(n-1)/\sin\theta_0\right] dh, \tag{24}$$

where h is the vertical altitude. Different range error models have been derived by solving Eqs. (23) and (24) in direct, linear approximation and discretized (or stratified) approaches. Note here that no effort has been made to examine or derive analytical expressions of models. Rather, it introduces main model equations to compare each approach. If one wants to understand further details of model expressions and their reasonings, please refer to the references provided for each model.

3.2.1. *Hopfield Range Error Model* [2]

Hopfield assumed that the lapse rate of temperature with respect to height is constant in the troposphere. A lapse rate of 6.8° C/km was assumed. Therefore, the functional form of the dry refractivity in the troposphere becomes a quartic. Hopfield used a linear approximation technique to solve Eq. (24) as

$$\Delta\rho_{tro} = \sum_{I} \Delta\rho_{I}, \tag{25}$$

where $I = 1$ denotes dry component, $I = 2$ wet component and

$$\begin{aligned}\Delta\rho_{I} = 10^{-6} N_{ti} \Big\{ & -l_1 + \left(4/h_{tro}^4\right)\Big[(1/3)\, r_T^2\, l_1^3 - (2/15)\, l_1^5 - (3/4)\, r_T\, r_{troi}^1\, l_1 \left(l_1^2 + (1/2)\, l_2^2\right) \\ & + r_{troi}^2\, l_1^3 - (1/2)\, r_{troi}^3\, r_T l_1 - (1/3)\, r_{troi}^2\, l_{3i}^3 + (2/15)\, l_{3i}^5 \\ & + (3/4)\, r_{troi}^2 \left(l_{3i}^3 + (1/2)\, l_{3i}\, l_2^2\right) - r_{troi}^2\, l_{3i}\left(l_{3i}^2 - (1/2) r_{troi}^2\right) \\ & + (1/2)\, r_{troi}\, l_2^2 \left((3/4)\, l_2^2 + r_{troi}^2\right) \ln\left[(r_T + l_T)/(r_{troi} + l_{3i})\right]\Big]\Big\},\end{aligned} \tag{26}$$

and $l_1 = r_T \sin\theta$, $l_2 = r_T \cos\theta$, $l_{3i} = \left(r_{troi}^2 - l_2^2\right)^{1/2}$, r_T and r_{troi} are distances from the center of the Earth to the ground tracking station and to the top layer of the troposphere (dry or wet component), respectively. Hopfield adopted the dry height to 40 km and the wet height to 12 km. Details of the derivation should be referred to Hopfield [2].

3.2.2. *Stratified Layer Model* [4, 16, 18]

If we limit ourselves with refraction in the vicinity of polar and equatorial regions where the effect of the Earth's magnetic field is an important consideration, it is a convenient and valid approximation to consider the atmosphere as consisting of several spherically stratified layers within a small segment of Earth surface like a 2.5° × 2.5° grid area in the globe. If this medium is slowly varying with height, it is then possible to assign numbers representing the mean value of the refractive index at any given time (i.e., 0000, 0600, 1200, 1800 h) for each of these layers. The bending of a ray as it traverses each successive layer is computed from a form of Snell's law that applies to spherically refracting surfaces. Snell's law for the refraction of electromagnetic waves at a plane interface between two mediums of index n_1 and n_2 is given by

$$n_1 \sin i_1 = n_2 \cos a_2, \tag{27}$$

where i_1 is the angle of incidence, and a_2 is the refraction angle in mediums n_1 and n_2, respectively. Consider the small vicinity around the point where the ray intersects the spherical boundary between the two different media, as Fig. 1 shows. If this region is chosen small enough to be physically and mathematically acceptable, it may be considered a plane and Snell's law be assumed to apply. Also, from the law of sines,

$$\sin i_1/r_1 = \sin\left(90° + \alpha_1\right)/r_2 = \cos \alpha_1/r_2. \tag{28}$$

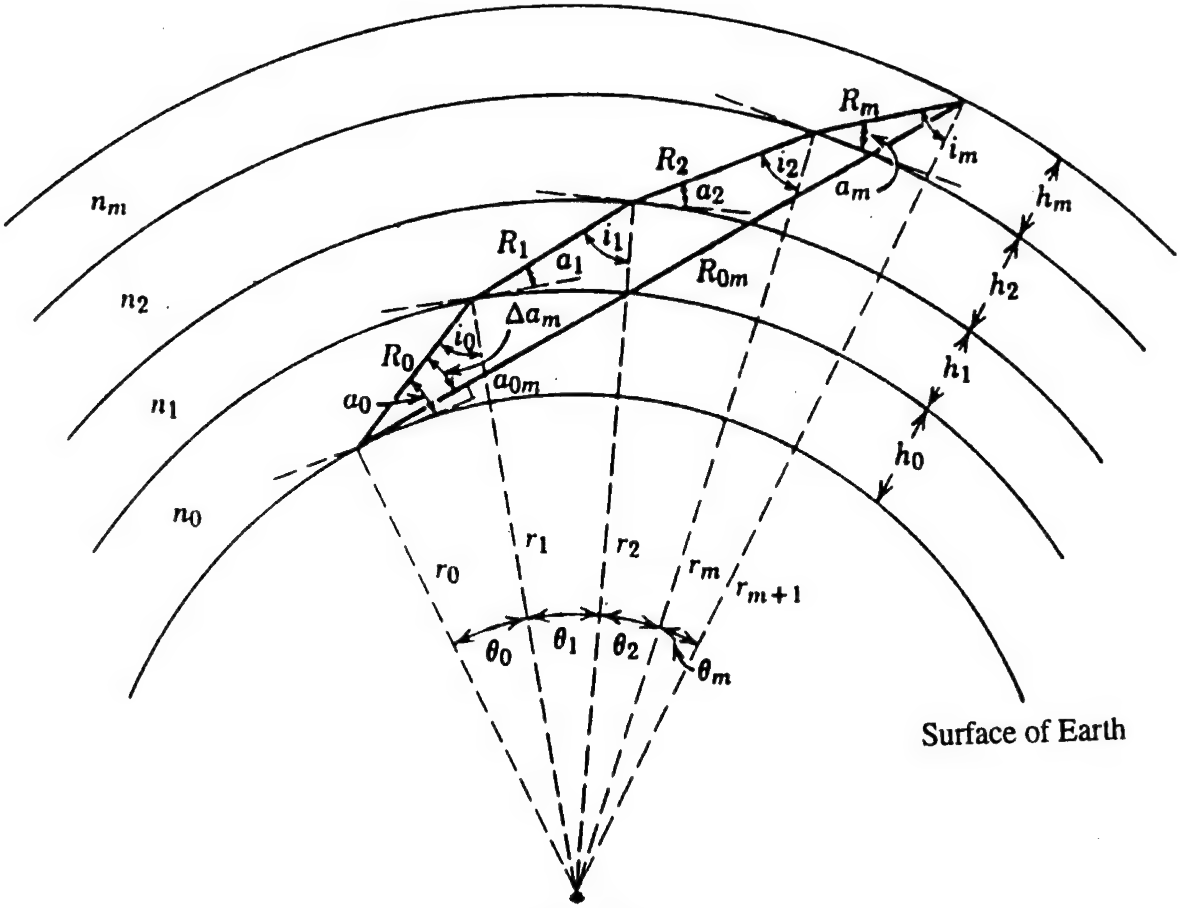


Fig. 1 — Progressive ray bending traversing spherical atmospheric layer stratification

Also,

$$\sin i_1 = (r_1/r_2) * \cos a_1 \tag{29}$$

Substituting Eqs. (28) and (29) into Eq. (27) yields Bouger's rule,

$$n_1 r_1 \cos a_1 = n_2 r_2 \cos a_2 . \tag{30}$$

The basic assumption that the proposed mathematical approach embodies is the following; the atmosphere is considered to be stratified into m spherical layers of thickness h_m and constant refractive index n_m. This type of stratification is seen in Fig. 1 where α_0 is the apparent elevation angle, and α_{0m} is the true elevation angle. The general expressions for α_m and i_m are given by

$$\alpha_m = \cos^{-1}\left[\left(n_{m-1}\, r_{m-1} / n_m\, r_m\right) \cos \alpha_{m-1}\right], \tag{31}$$

and

$$i_m = \sin^{-1}\left[\left(r_m / r_{m+1}\right) \cos \alpha_m\right], \tag{32}$$

where the radial distance r_{m+1} is merely the summation of the various layers expressed by

$$r_{m+1} = r_0 + \sum_{j=0} h_j . \tag{33}$$

Applying the law of sines for the direct path, it follows that

$$\alpha_{0m} = \cos^{-1} \left\{ \left(r_{m+1} / R_{0m} \right) \sin \left[\sum_{j=0} \theta_j \right] \right\}, \tag{34}$$

where

$$R_{0m}^2 = r_0^2 + r_{m+1}^2 - 2r_0 \; r_0 r_{m+1} \cos \left[\sum_{j=0} \theta_j \right], \tag{35}$$

and

$$\theta_j = \pi/2 - \alpha_j - i_j . \tag{36}$$

The refraction angle error $\Delta\alpha_m$, which is the difference between the apparent elevation angle and the true elevation angle, can then be determined from

$$\Delta\alpha_m = \alpha_0 - \alpha_{0m} . \tag{37}$$

Similarly, the range error ΔR, which results from the velocity of propagation being less than the free space velocity and from an increase in path length brought about by the refractive bending of the ray, reduces to

$$\Delta R = \sum_{j=0} \left(R_j * n_j \right) - R_{0m}, \tag{38}$$

where the distance R_j is given by

$$R_j^2 = r_j^2 + r_{j+1}^2 - 2 r_j r_{j+1} \cos \theta_j . \tag{39}$$

Since the validity of Snell's law or Bouger's law depends upon the thickness of layers, the performance of the stratified model largely depends on the number of layers in the process. The total number of layers is 45 in this report and is specified in the following manner:

$h = 0 - 100$ m	10 layers with 10-m interval	
$h = 100 - 1{,}000$ m	9 layers with 100-m interval	
$h = 1{,}000$ m and above	26 layers with 1,000-m interval.	(40)

The main reason for this division is based on the fact that the refractive effect is small above 10 km from the surface of the Earth. The test has been performed in order to validate this argument of 45 layers by computing range and angle errors on different environments with spatial, temporal, and geographical variations. This approach provides both range and angle errors with straightforward mathematical and computational expressions.

3.2.3. Goad Model [6]

This model results from the combination of the Hopfield [2] and Saastamoinen [19] models. Goad modified the value of the tropospheric height into a Taylor's series approximation in terms of range rather than a quartic form as proposed by Hopfield as

$$h = r\sin\theta + \left(r^2\cos^2\theta\right)/2a_e, \tag{41}$$

where h is height, r the range, θ the elevation angle, and a_e the semimajor axis of the Earth.

The range correction ΔR is computed as:

$$\Delta R = 10^{-6}\int_0 \mathrm{N}_0(r)\,dr + 10^{-6}\int_0 N_1(r)\,dr$$

$$= 10^{-6}\sum_{I=0} N_1\ (0)\left[a_{1,I}\,r_i + \left(a_{2,I}/2\right)r_i^2 + \ldots + \left(a_{9,I}/9\right)r_i^9\right], \tag{42}$$

where N_0 is the surface dry refractivity, and N_1 the wet refractivity

$$r_i = \sqrt{\left(a_e + h_i\right)^2 - a_e^2\cos^2\theta} - a_e\sin\theta, \qquad \text{for } I = 0, 1$$

$$h_0 = 5(0.002277)p/N_0{*}10^{-6}$$

$$h_1 = \left[5(0.077)/\left(N_1 * 10^{-6}\right)\right] * \{1255/T + 0.5\} * e$$

$\alpha_{1I} = 1,$ $\qquad$ $\alpha_{2I} = 4\,a_i$

$\alpha_{3I} = 6a_i^{\,2} + 4b_i$ $\qquad$ $\alpha_{4I} = 4\,a_i\left(a_i^2 + 3b_i\right)$

$\alpha_{5I} = a_i^4 + 12a_i^2\,b_i + 6b_i^2$

$\alpha_{6I} = 4a_i\,b_i\left(a_i^2 + 3b_i\right),$ $\qquad$ $\alpha_{7I} = b_i^2\left(6\,a_i^2 + 4b_i\right)$

$\alpha_{8I} = 4a_i\,b_i^3,$ $\qquad$ $\alpha_{9I} = b_i^4$

$a_i = \sin\theta/h_i,$ $\qquad$ $b_i = -\cos^2\theta/\left(2\,a_e\,h_i\right)$

$$e = 6.108 * RH * \exp[(17.15T - 4684)/(T - 38.45)]$$

$I = 0$: dry refractive component, $\quad I = 1$: wet refractive component

Δr: range correction in m, subtract from pseudo range or carrier phase
T: surface temperature in K (= °C + 273.16)
p: atmospheric pressure in mbar
e: water vapor partial pressure in mbar
θ: elevation angle tangent to the horizon
a_e: semimajor axis of the Earth ellipsoid
RH : relative humidity as a fraction of 1.0

Similarly the elevation angle correction is obtained as

$$\Delta\theta(r) = \int_0 d\theta = 4 \cos\theta_0 \sum_{i=0} \left\{ X_{1,i}\, R + X_{2,i}\, R^2/2 + \ldots + X_{7,i}\, R^2/7 \right\}, \tag{43}$$

where

$$X_{1,i} = 1$$

$$X_{2,i} = 3a_i$$

$$X_{3,i} = 3(a_i^2 + b_i)$$

$$X_{4,i} = a_i\,(6\,b_i + a_i^2)$$

$$X_{5,i} = 3\,b_i\,(b_i + a_i^2)$$

$$X_{6,i} = 3\,a_i\,b_i^2$$

$$X_{7,i} = b_i^3$$

and other parameters are already defined above. As pointed out before, this model covers both below 5° elevation angle and between 5° and 20° in contrast with Hopfield's model, which covers only above 5° elevation angles. Test and evaluation of this model was somewhat limited to a couple of data samples.

3.2.4. Blake Model [5]

Blake developed a technique to find the position coordinates of the point on the Earth's surface that lies directly below the target, which amounts to finding the ground range (distance from the antenna to the target point measured along the Earth's surface at sea level). Further quantities of interest are the straight line distance from antenna to target and the true elevation angle (as opposed to the apparent angle indicated by the antenna). Consider the ray tracing equation, which is Snell's law for a spherically symmetric medium,

$$\cos\theta = \left[n_0 \cos\theta_0\right]/n(h)\,\left(1 + h/r_0\right), \tag{44}$$

where θ_0 is the initial elevation angle at $h = 0$, r_0 the distance from the Earth's center to the initial point, n_0 the refractive index at $h = 0$ height, and h the ray height above its initial point. Substituting Eq. (44) into Eq. (24), one can obtain the range error as

$$R\ (h_1, \theta_0) = \int_{h_0}^{h_1} ndh \Big/ \left[1 - \sqrt{\left\{n_0 \cos\theta_0 / \left[n(1 + h/r_0)\right]\right\}^2}\,\right].$$

(45)

A similar procedure yields for the ground range as

$$G\ (h_1, \theta_0) = \int_{h_0}^{h_1} dh \Big/ \left[\left[(1 + h/r_0)\right] * \sqrt{\left[\left\{n(1 + h/r_0)\right\}/n_0\ \cos\theta_0\ \right]^2 - 1}\ \right]. \qquad (46)$$

In Fig. 2, the quantity R' is the geometric length of the ray path. The corresponding distance R, measured by a radar that assumes the wave-propagation speed to be that for free space (the speed of light $c = 2.997925 \times 10^8$ m/s), is related to R' by the differential expression

$$dR = n\ dR'. \qquad (47)$$

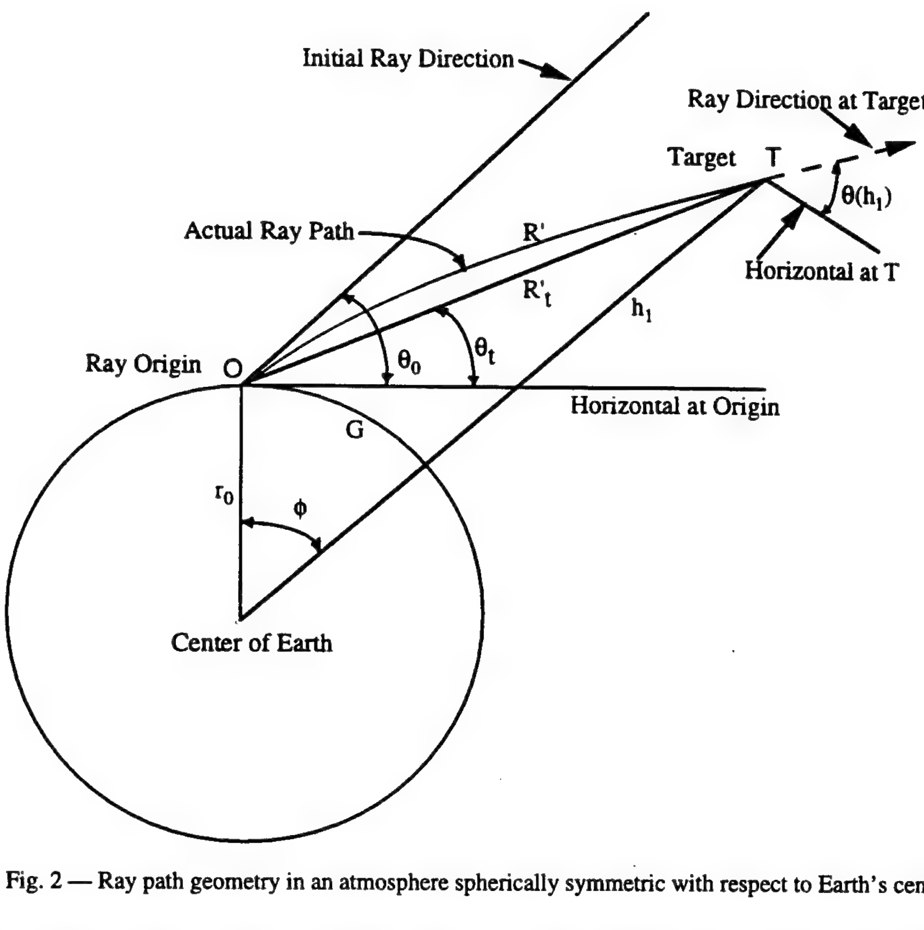


Fig. 2 — Ray path geometry in an atmosphere spherically symmetric with respect to Earth's center

The quantity R given by Eq. (45) is the radio path range. The distance G given by Eq. (46) is the ground range equal to $r_0\phi$. The particular refractive index profile for which computations have been carried out is of the form

$$n(h') = 1 + \rho_s \exp\left[-k(h' - h_s)\right], \qquad (48)$$

where k is a decay constant, and $(1+\rho_s)$ is the value of n at $h' = h_s$: that is, h_s is a reference height. If the ray origin is at some height h_a (antenna height) and h is measured with respect to the antenna, the expression (Eq. (48)) becomes

$$n(h) = 1 + \rho_0 \exp(-kh)\,, \tag{49}$$

where
$$\rho_0 = \rho_s \exp\left[-k(h_a - h_s)\right]. \tag{50}$$

At small values of θ_0, the integrands of Eqs. (45) and (46) are subject to the loss of accuracy in the vicinity of $h = 0$. Blake manipulated the integral equations for numerical computations as

$$R\,(h_1, \theta_0) = \int_{h=0} \left\{n^2\,(1+\ h/r_0)dh\right\} \Big/ \sqrt{u+v+w+vw}\,, \tag{51}$$

$$G(h_1, \theta_0) = \int_{h=0} \left\{(1+\ \rho_0)(\cos\theta_0)dh\right\} \Big/ \left[(1+\ h/r_0)\,(1+\ h/r_0)\,\sqrt{u+v+w+vw},\right] \tag{52}$$

where $n = 1 + \rho_0 \exp(-kh)$

$$u = (1+\rho_0)^2 \sin^2\theta_0 - 2\rho_0 - \rho_0^2$$

$$v = \rho_0 \exp(-kh) + \rho_0^2 \exp(-2kh)$$

$$w = 2h/r_0 + h^2/r_0^2\,.$$

These formulations are obtained by replacing $\cos^2\theta_0$ with its equivalent, $\left(1-\sin^2\theta_0\right)$. At $\theta_0 = 0$, the quantity u is a small negative number, but above about $\theta_0 = 1.5°$, it becomes positive. In the region close to $\theta_0 = 0$ and $h = 0$, a special procedure is required. As pointed out, Blake's model took into consideration the low elevation angle (below 5°) to compensate the shortfalls of Hopfield's model, which is valid only above 5°. Blake also developed a technique to compensate the range error for the over-the-horizon atmospheric effects by using Eq. (46) rather than Eq. (45) alone (note: most models use a single expression for the range integration).

Similarly, equations for the true geometric range R_t, and the true elevation angle θ_t are manipulated as

$$R_t = \sqrt{\ }\ \sqrt{h_1^2 + 4r_0\,(r_0 + h_1)\sin^2\,(G/2r_0)}\,, \tag{53}$$

$$\theta_t = \sin^{-1}\ \left[h_1/R_t + h_1^2/2r_0\,R_t - R_t/2r_0\right] \qquad \text{for } \theta_0 \le \pi/4, \tag{54}$$

$$\theta_t = \pi/2 - \sin^{-1}\ \left[\left\{(r_0 + h_1)\sin\left(G/r_0\right)\right\}/R_t\right] \qquad \text{for } \theta_0 \ge \pi/4. \tag{55}$$

Note that the accuracy of all of these results is heavily dependent on the accuracy of the calculation of G. The elevation angle error can be obtained readily by subtracting the true elevation angle of Eqs. (54) and (55) from the actual elevation angle.

3.2.5. Cain's Model [20]

This model was developed by D.L. Cain of the Jet Propulsion Laboratory (JPL), Pasadena, California, in the late 1960s or early 1970s, for deep-space communication-link correction. A direct reference for Cain's work could not be found, but a brief outline of his model was given in Moyer [20] and Gallini [21]. This model is one of the closest models to the modified exponential model. Thus, this model is included with other model performances for comparison purposes. The model has the form for range delay ΔR as:

$$\Delta R = \left(C_4 / 340 * N_s\right) / \left[\left(C_2 \sin E + C_1\right) * \sin E + C_0\right]^{C3} \qquad \text{[m]} \tag{56}$$

N_s = station surface refractivity index

E = geometric elevation angle

C_0 = 0.06483 [unitless]

C_1 = 1.0 [unitless]

C_2 = 0.0 [unitless]

C_3 = 1.4 [unitless]

C_4 = 0.0018958 [km] .

This model has been implemented in the Air Force Satellite Control Network Tracking and Orbit Determination program and uses a table of monthly averages for the surface refractivities. According to Ref. 21, current monthly averages are somewhat low, and the formula itself results in inaccurate refractivities. For a given refractivity, the formula produces a correction of 14 m at 10° elevation angle, which is a reasonable value.

3.2.6. Case 1 Model

Since no reference for this model could be found, we called it Case 1 Model. This model has been adopted in the program for more than a decade without any proof or verification of its validity. The origin of this model was derived from Figs. 1-4 and 1-5 of Millman [4] for both elevation angle and range error plots, respectively, by segmenting into three parts and then computing coefficients through least-square-fit approach. This is similar to Cain's model except for separation into three parts based on elevation angle. The range delay ΔR in meters is given by

$$\Delta R = 0.3048006/[0.003589 + (0.087605 \sin E + 0.19696793 \sin^2 E)] \qquad \text{for } E \le 5^\circ, \tag{57a}$$

$$\Delta R = 0.3048006/[0.002129 + 0.12158 \sin E] \qquad \text{for } 5 \le E \le 30^\circ, \tag{57b}$$

$$\Delta R = 0.3048006/[0.03 + 0.08 \sin E] \qquad \text{for } E \ge 30^\circ, \tag{57c}$$

where E denotes the elevation angle, and c is the speed of light, 299.792458 $*10^5$ km/s. The time delay can be calculated readily by dividing range error by c. Note here that both this model and Cain's model do not provide an angle error formula and are similar.

3.3. Proposed Approach

Here we propose the approach that combines both the modified exponential refractivity model and the stratified range/angle error model presented above. This approach gives more accurate range and angle error performance in the low elevation angle below 10° in comparison with that of other models. Refractivity can be generated without any limitation of altitude from ground to the top of the tropospheric layer and is closer to the empirical data than any other approach. This model may also be implemented easily for a combination of tropospheric and ionospheric effects and can be extended to the ionospheric layer without difficulty. The total storage (only 7 Mbps) and programming requirements (< 100 lines of coding) are minimal except for the database of the 2.5° × 2.5° worldwide reference heights, which can be updated every 5 to 10 yr depending upon the user's accuracy requirements. Test and analysis results are given in the next section.

4. PERFORMANCE COMPARISON OF EACH MODEL

Evaluation of model performance is emphasized mainly on temperature, relative humidity, refractivity distribution and its gradient, time delay, range error, and elevation angle error over more than 130 areas of interest (AOIs) with worldwide coverage in geographical, climatological, surface altitude, seasonal, diurnal, hourly, marine, and polar regions. Methodology of data representation varies with characteristics of data contents by graphs, tables, contours, and colors. Since the volume of analysis results are enormous, the majority of data is included in the Appendixes. Data are divided into three parts: 10 AOIs, 46 AOIs, and 130 AOIs, depending upon the number of variables for the comparison purposes. The comparison is divided into two parts—the first on refractivity and meteorological parameters (temperature, relative humidity, pressure, and refractivity and the second on propagation errors. Figure 3 shows the 10 AOI locations selected for simplification of data handling to analyze first-hand geographical performance variations. Figure 4 presents 46 AOIs selected to study further details and trends of model performance for different geographical and climatological regions. Table 1 presents the total number of AOIs examined in this report for evaluation of model performance and data quality verification and validation. Table 1 contains full descriptions and abbreviations of all AOIs considered here with latitude and longitude boundaries and number of grids in that area. Note here that some portions of data have been interpolated or extrapolated based on the availability of raw data because original data have portions of missing or erroneous data for some grids or areas. All data analyses presented in this report are based on three categories of data groups: 10, 46, or 130 AOIs.

4.1 Refractivity and Meteorological Parameters

Figures 5 and 6 show the worldwide ECM data distribution of refractivities for February and August, respectively, for 15° intervals of latitude and 45° intervals of longitude. Higher refractivity regions for August (Fig. 5) are in the Northern Hemisphere with higher refractivity regions in the Southern Hemisphere during February (Fig. 6). Refractivities for areas of 30° latitude of Northern Hemisphere and 30° latitude of Southern Hemisphere are much higher than the worldwide average, 332 to 340 N-units depending on time of the day. Table 2 presents 46 AOIs with latitude, longitude, mountain (M), land (L), water (W), continents, and climates. These 46 AOIs are selected to cover weighted areas of desert, ocean, rain forest, tropical, temperate, and polar regions for fair evaluation of model performance equally and evenly. Table 3 shows the monthly surface refractivity for 46 AOIs of ECM surface data. Note here that

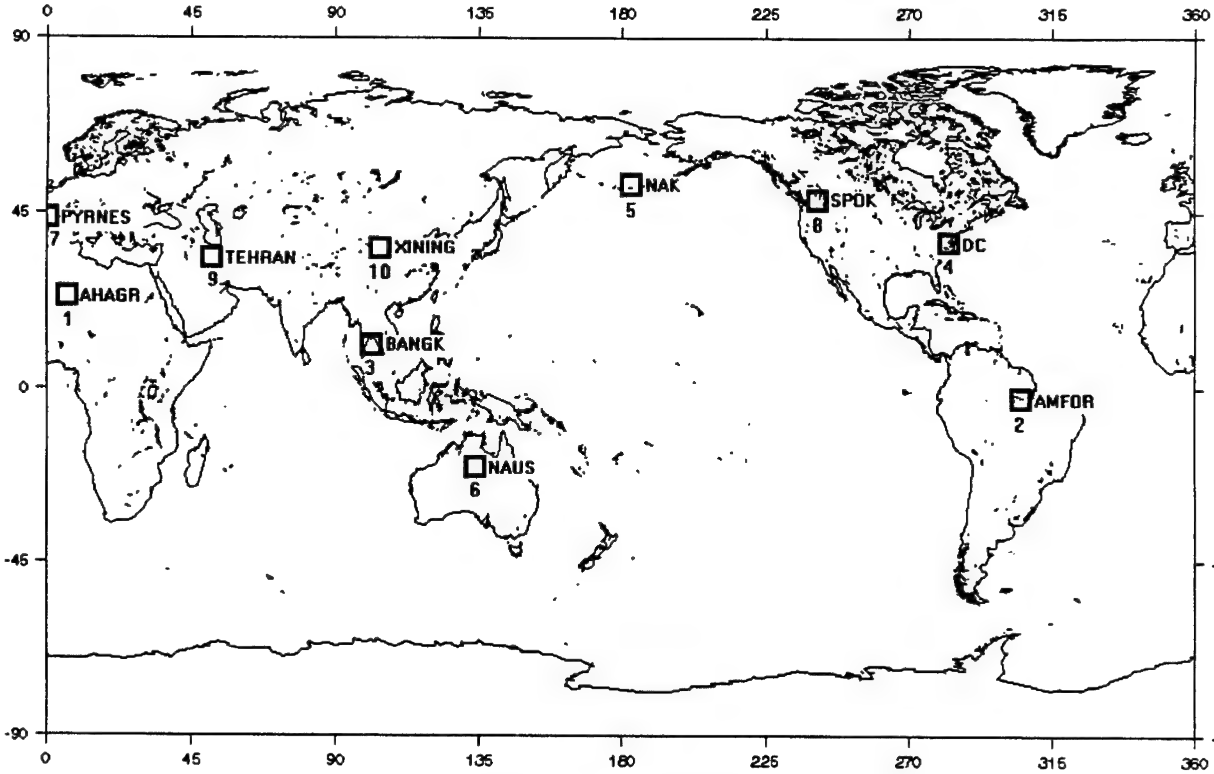


Fig. 3 — Ten AOI locations

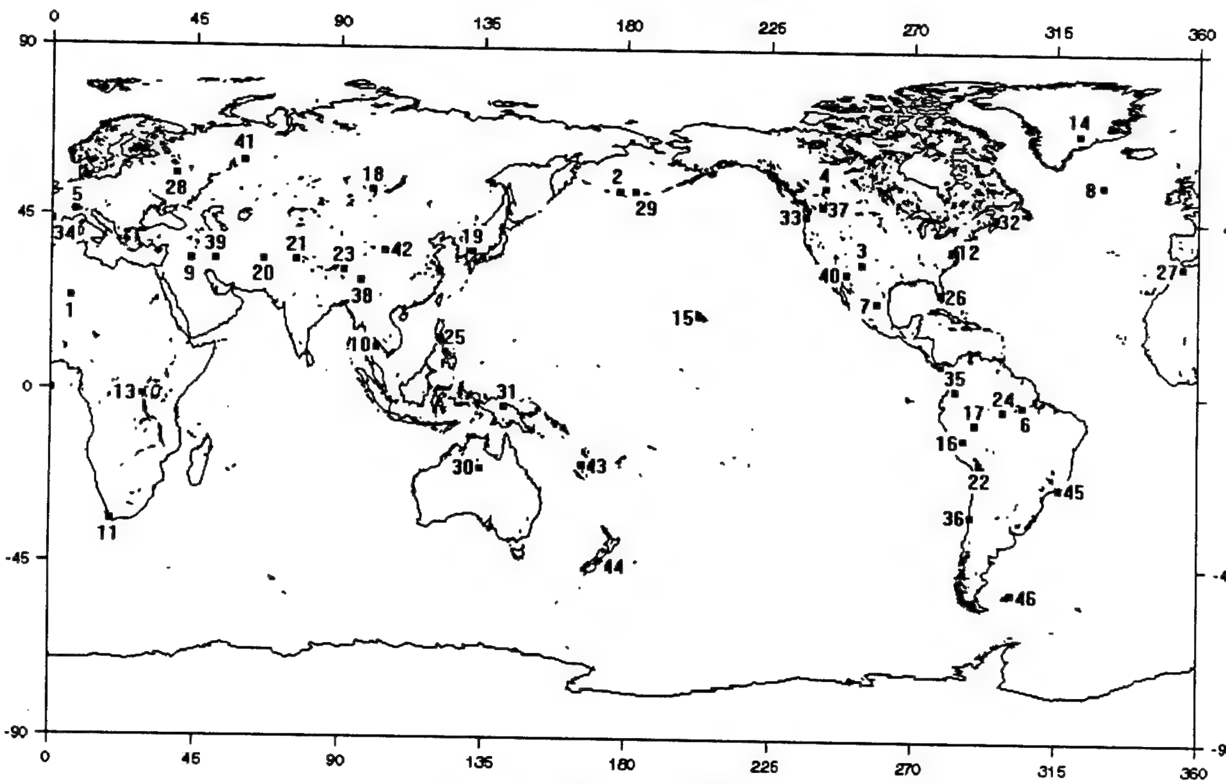


Fig. 4 — Forty-six AOI locations

Table 1 — Selected Areas of Interest

AOI #	Description	AOI	Lo LAT	HI LAT	Lo ELON	HI ELON	# of Grids
1	Eastern US	EUS	22.5	55.0	260.0	300.0	208
2	Western US	WUS	22.5	55.0	225.0	260.0	182
3	Northeast US	NEUS	40.0	50.0	285.0	300.0	24
4	Midwest US	MWUS	30.0	45.0	245.0	260.0	36
5	Alaska	AK	45.0	60.0	165.0	190.0	60
6	Southeast US Region 3	SEUS3	8.0	32.5	275.0	285.0	39
7	Europe	EUR	35.0	70.0	345.0	45.0	336
8	Persian Gulf	PG	10.0	45.0	30.0	70.0	224
9	Mediterranean	MED	27.5	50.0	345.0	45.0	216
10	Mid-Indian Ocean	MIO	-15.0	5.0	60.0	90.0	96
11	Far East	FE	22.5	50.0	115.0	155.0	176
12	Northwest Pacific	NWP	5.0	22.5	135.0	155.0	56
13	Canada Belt	CAN	47.5	60.0	230.0	310.0	160
14	Central America	CAM	7.5	22.5	260.0	290.0	72
15	Amazon Forest	AMFOR	-15.0	10.0	285.0	325.0	160
16	South Africa	SAF	-35.0	-25.0	15.0	35.0	32
17	Sahara Desert	SAH	10.0	30.0	15.0	40.0	80
18	Australia Continent	AUS	-40.0	-10.0	110.0	155.0	216
19	Southeast Asia Region 1	SEAS1	-10.0	20.0	75.0	105.0	144
20	Southeast Asia Region 2	SEAS2	-10.0	20.0	105.0	135.0	144
21	Gobi Desert	GOBI	37.5	47.5	85.0	112.5	44
22	Eurasia Belt	EURAS	40.0	60.0	30.0	90.0	192
23	Siberia	SIB	60.0	80.0	60.0	180.0	384
24	New Alaska	NAK	45.0	60.0	170.0	195.0	60
25	State of Maine	MAINE	42.5	47.5	287.5	292.5	4
26	Boston, Massachusetts	BOSTN	40.0	42.5	290.0	292.5	1
27	New York, New York	NYC	40.0	42.5	287.5	290.0	1
28	Ocean City, Maryland	OCNCY	37.5	40.0	285.0	287.5	1
29	Virginia Beach, Virginia	VABCH	35.0	37.5	282.5	285.0	1
30	Myrtle Beach, South Carolina	MYRBC	32.5	35.0	280.0	282.5	1
31	Jacksonville, Florida	JAX	30.0	32.5	277.5	280.0	1
32	Miami, Florida	MIA	25.0	27.5	277.5	280.0	1
33	Burlington, New Hampshire	BURL	42.5	45.0	285.0	287.5	1
34	Buffalo, New York	BUFF	42.5	45.0	280.0	282.5	1
35	Pittsburgh, Pennsylvania	PITT	40.0	42.5	280.0	282.5	1
36	Charleston, West Virginia	CHWV	37.5	40.0	277.5	280.0	1
37	Asheville, North Carolina	ASHVL	35.0	37.5	275.0	277.5	1
38	Atlanta, Georgia	ATL	32.5	35.0	275.0	277.5	1
39	Tallahassee, Florida	TALL	30.0	32.5	272.5	275.0	1
40	Columbus, Ohio	COL	37.5	40.0	275.0	277.5	1
41	Nashville, Tennessee	NASH	35.0	37.5	272.5	275.0	1
42	Jackson, Mississippi	JACMS	30.0	32.5	267.5	270.0	1
43	Duluth, Minnesota	DUL	45.0	47.5	265.0	267.5	1
44	Chicago, Illinois	CHI	40.0	42.5	270.0	272.5	1
45	Kansas City, Missouri	KC	37.5	40.0	265.0	267.5	1
46	Dallas, Texas	DAL	32.5	35.0	262.5	265.0	1
47	San Francisco, California	SF	37.5	40.0	237.5	240.0	1
48	Los Angeles, California	LA	32.5	35.0	240.0	242.5	1
49	Portland, Oregon	PORT	45.0	47.5	235.0	237.5	1
50	Spokane, Washington	SPOK	47.5	50.0	240.0	242.5	1
51	Boise, Idaho	BOIS	42.5	45.0	242.5	245.0	1
52	Hawthorne, Nevada	HAWNV	37.5	40.0	240.0	242.5	1
53	Las Vegas, Nevada	LASV	35.0	37.5	242.5	245.0	1
54	Tucson, Arizona	TUCS	30.0	32.5	247.5	250.0	1
55	Cedar City, Utah	CCUT	35.0	37.5	245.0	247.5	1
56	Livingston, Montana	LIVMT	45.0	47.5	247.5	250.0	1
57	Rock Spring, Wyoming	RSWY	40.0	42.5	250.0	252.5	1
58	Colorado Springs, Colorado	CSCO	37.5	40.0	252.5	255.0	1
59	Albuquerque, New Mexico	ALBQ	32.5	35.0	252.5	255.0	1
60	Laredo, Texas	LAR	27.5	30.0	260.0	262.5	1
61	High Alt Area in North Am: New Mex, Ariz & Col	HAAM	32.5	42.5	245.0	257.5	20
62	North & South Dakota	NDSD	42.5	50.0	255.0	265.0	12
63	West Cost US: Washington & Oregon State	WCUS	42.5	50.0	235.0	240.0	6
64	Washington, D.C.	DC	35.0	40.0	280.0	285.0	4
65	West Africa: Northwest Coast	NWAFR	2.5	17.5	340.0	355.0	36
66	Northwest Africa: Morocco	MOR	30.0	37.5	352.5	357.5	6

Table 1 (Continued) — Selected Areas of Interest

67	Greater Australia Continent	GRAUS	-30.0	-10.0	110.0	160.0	160
68	Northern Australia: Tanami Desert	NAUS	-25.0	-15.0	130.0	137.5	12
69	Antarctic Circle	ANT	-90.0	-65.0	0.0	360.0	1440
70	Northern China Desert	NCHD	35.0	47.5	75.0	95.0	40
71	West Indian Coast	WIC	10.0	25.0	60.0	75.0	36
72	High Altitude Area in Asia: Himalayan Mtns	HIM	20.0	30.0	60.0	90.0	48
73	Far East: Korea & Japan	KJ	30.0	45.0	125.0	140.0	36
74	Middle East	ME	25.0	40.0	45.0	65.0	48
75	South America: Chile & Argentina	CHAG	-55.0	-35.0	285.0	295.0	32
76	East Coast of Brazil	EBRZ	-30.0	-10.0	310.0	325.0	48
77	West Coast of South America	WSAM	-30.0	0.0	277.5	295.0	84
78	Northern Tip of South America	NSAM	-12.0	-7.5	282.5	300.0	13
79	West Coast of Mexico	WMEX	20.0	32.5	242.5	250.0	15
80	North America: Alaska State	NALAS	57.5	75.0	195.0	225.0	84
81	Northern Canada	NCAN	60.0	75.0	230.0	300.0	168
82	Greenland	GRNL	60.0	85.0	290.0	350.0	240
83	Western Russia: Moscow Vicinity	WRUS	50.0	65.0	20.0	60.0	96
84	Eastern Russia	ERUS	45.0	70.0	80.0	130.0	200
85	Pacific Ocean: Polynesian Islands	POL	-30.0	10.0	180.0	230.0	320
86	Ahaggar, Algeria	AHAGR	22.5	25.0	5.0	7.5	1
87	Alberta, Canada (Rockies)	ALBRTA	52.5	55.0	240.0	245.0	2
88	Alp Mountains	ALPS	45.0	47.5	5.0	10.0	2
89	Antartica	ANTHI	-85.0	-72.5	10.0	122.5	225
90	Aguas, Mexico	AQUAS	22.5	25.0	257.5	260.0	1
91	East Congo (Zaire)	ECONGO	-7.5	5.0	27.5	30.0	5
92	Ethiopia	ETHIOP	0.0	7.5	40.0	42.5	3
93	Greenland	GRNLHI	67.5	70.0	320.0	325.0	2
94	Greenland (North)	GRNLN	72.5	80.0	320.0	330.0	12
95	Greenland (South)	GRNLS	62.5	67.5	310.0	320.0	8
96	Huancayo, Peru (Andes)	HUANCO	-12.5	-10.0	285.0	287.5	1
97	Irkutsk, Siberia	IRKTSK	50.0	55.0	97.5	102.5	4
98	Kabul, Afghanistan	KABUL	32.5	35.0	65.0	67.5	1
99	Kashmir, India (Himalayas)	KASHMR	32.5	35.0	75.0	77.5	1
100	LaPaz, Bolivia (Andes)	LAPAZ	-20	-15	290	292.5	2
101	Lhasa, Tibet (Himalayas)	LHASA	30.0	32.5	90.0	92.5	1
102	Lanzhou, China	LNZHU	35.0	37.5	100.0	102.5	1
103	New Guinea	NGUIN	-5.0	-2.5	140.0	142.5	1.
104	Pyrenee Mountains	PYRNES	42.5	45.0	357.5	2.5	2
105	Quito, Ecuador (Andes)	QUITO	0.0	2.5	282.5	285.0	1
106	Santiago, Chile (Andes)	SANTGO	-32.5	-30.0	287.5	290.0	1
107	Tangmai, Tibet	TANGMI	27.5	30	92.5	100	3
108	Tehran, Iran	TEHRAN	32.5	35.0	50.0	52.5	1
109	Ural Mountains	URALS	57.5	62.5	57.5	62.5	4
110	Xining, China (Himalayas)	XINING	35.0	37.5	102.5	105.0	1
111	Atlantic North Central Equator	ATL00C	0.0	10.0	335.0	345.0	16
112	Atlantic North Central 10 lat	ATL10C	10.0	20.0	315.0	330.0	24
113	Atlantic North Tropic of Cancer	ATL20C	20.0	30.0	315.0	325.0	16
114	Atlantic North Central 30 lat	ATL30C	30.0	40.0	310.0	330.0	32
115	Atlantic North Central 40 lat	ATL40C	40.0	50.0	320.0	335.0	24
116	GIUK (Grnland, Iceland, UK)	ATL50	50.0	60.0	320.0	340.0	32
117	Atlantic South (Ascension Ilse)	ATLS2	-10.0	0.0	340.0	350.0	16
118	Atlantic South (Trnidade Brazil Ilse)	ATLS4	-30.0	-15.0	325.0	335.0	24
119	Atlantic South (Nightingale Ilse)	ATLS6	-40.0	-35.0	340.0	5.0	20
120	Bangkok, Thailand	BANGK	10.0	12.5	100.0	102.5	1
121	Baghdad, Iraq	BAGDAD	32.5	35.0	42.5	45.0	1
122	Korea & Japan (Lower Sea of Japan)	JAPSEA	32.5	40.0	125.0	137.5	15
123	Cape Town, South Africa	CAPTOW	-35.0	-32.5	17.5	20.0	1
124	Moscow, Russia	MOSCOW	55.0	57.5	37.5	40.0	1
125	Prince Edward Island, Canada	PEILSE	45.0	47.5	295.0	297.5	1
126	Manaus, Brazil (Amazon Forest)	MANAUS	-5.0	-2.5	297.5	300.0	1
127	New Caledonia	NEWCAL	-20.0	-17.5	165.0	167.5	1
128	New Zealand	NEWZEA	-45.0	-42.5	170.0	172.5	1
129	Rio de Janerio	RIODEJ	-25.0	-22.5	315.0	317.5	1
130	Falklands	FALKLD	-52.5	-50.0	300.0	302.5	1

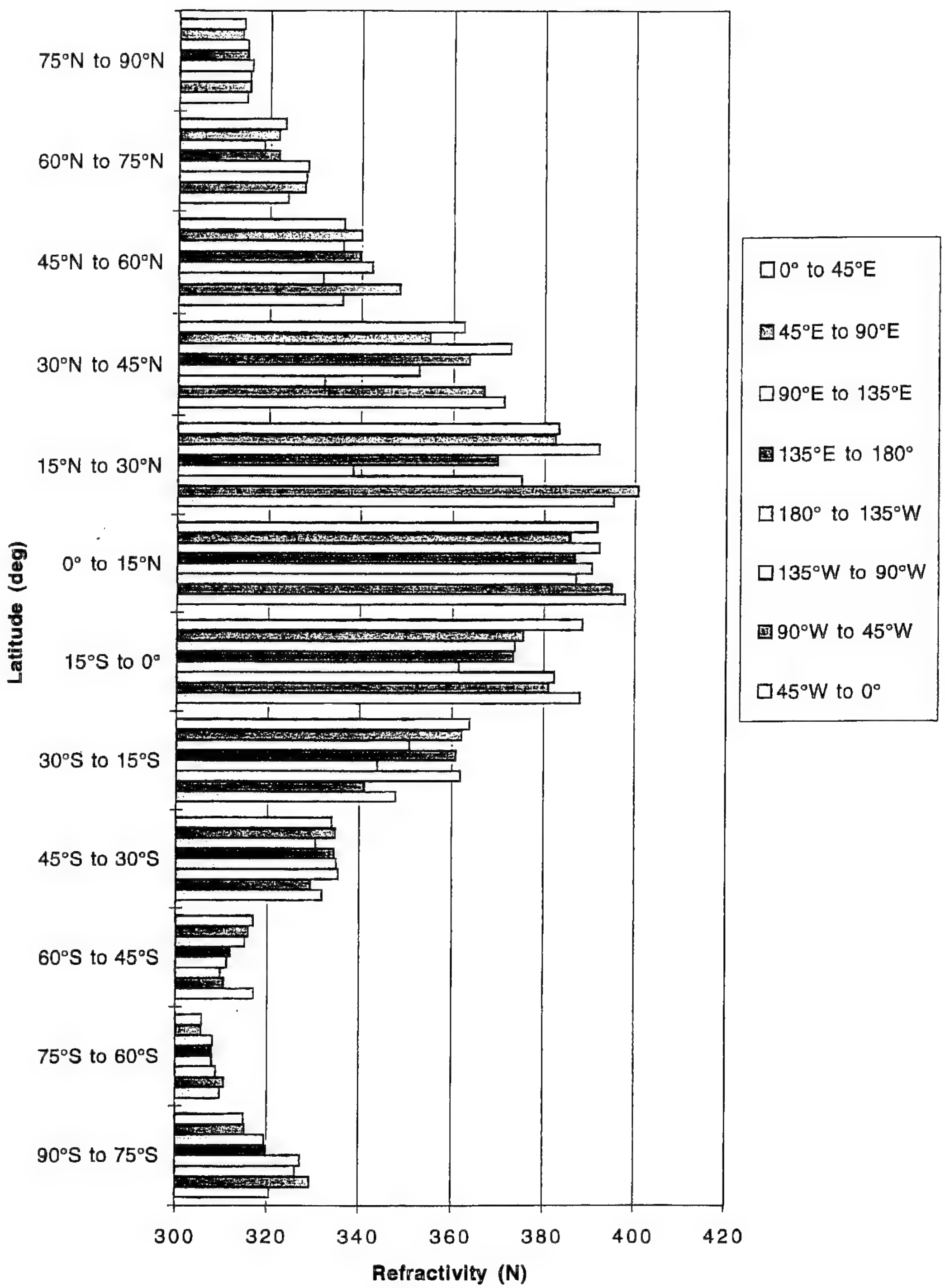


Fig. 5 — ECM worldwide refractivities (August)

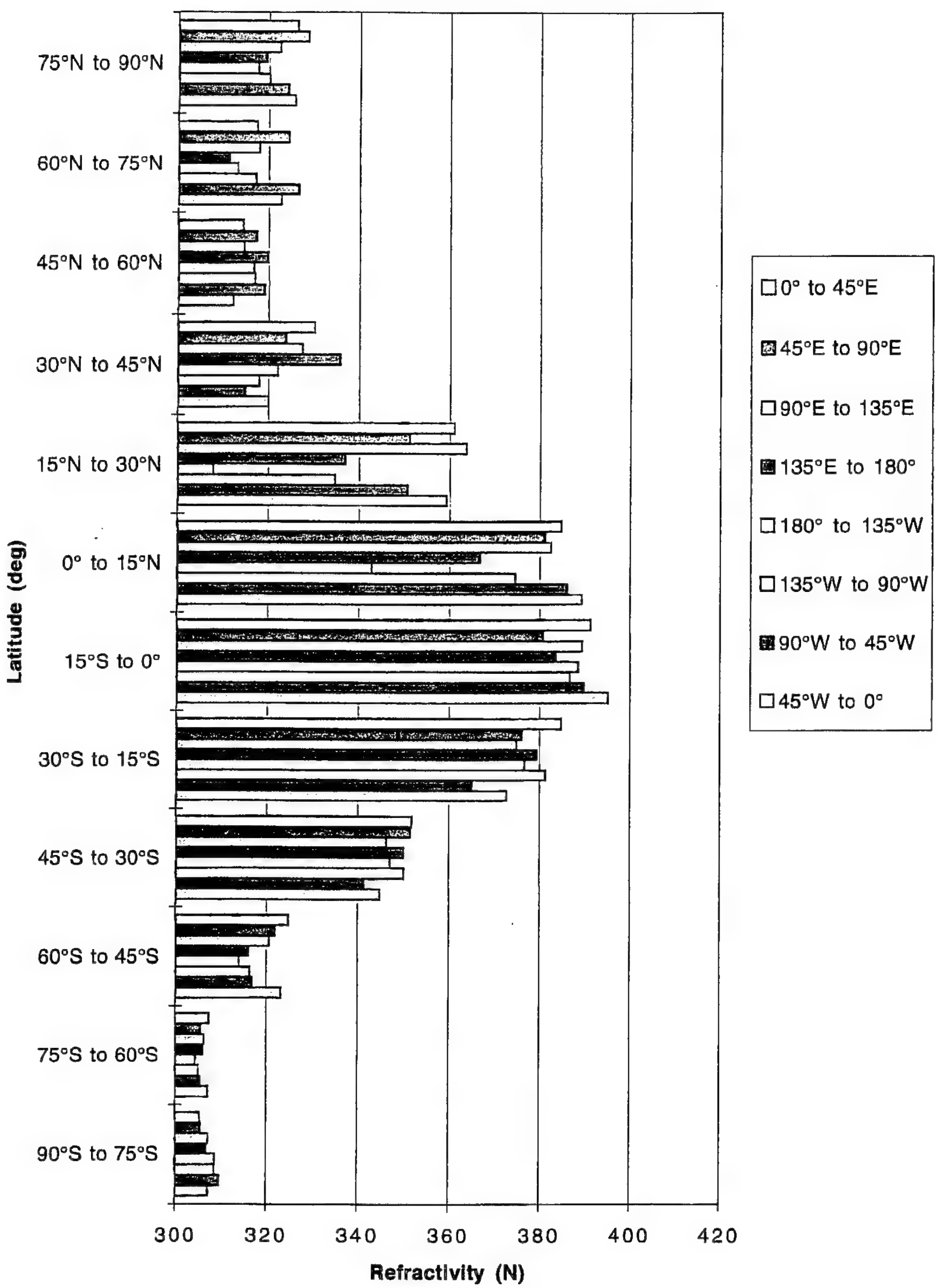


Fig. 6 — ECM worldwide refractivities (February)

Table 2 — Definitions and Characteristics for 46 Areas of Interest

#	AOI	LO LAT	HI LAT	LO LON	HI LON	# of Grids	Type	Continent	Climate
1	Ahaggar, Algeria (AHAGR) (1)	22.5	25.0	5.0	7.5	1	M	Africa	SUBTROPICAL
2	Bering Sea (AK) (2)	45.0	60.0	165.0	190.0	60	W	WATER/Pac	BOREAL
3	Albuquerque, New Mexico (ALBQ) (3)	32.5	35.0	252.5	255.0	1	L	North America	TEMPERATE
4	Alberta, Canada (ALBRTA) (4)	52.5	55.0	240.0	245.0	2	M	North America	TEMPERATE
5	Alp Mountains (ALPS) (5)	45.0	47.5	5.0	10.0	2	M	Europe	TEMPERATE
6	Amazon Forest (AMFOR) (6)	-15.0	10.0	285.0	325.0	160	LW	South America	TROPICAL
7	Aquas, Mexico (AQUAS) (7)	22.5	25.0	257.5	260.0	1	M	North America	TROPICAL
8	Greenland, Iceland, UK (ATL50) (8)	50.0	60.0	320.0	340.0	32	W	WATER/Atl	TEMPERATE
9	Baghdad, Iraq (BAGDAD) (9)	32.5	35.0	42.5	45.0	1	L	Asia	SUBTROPICAL
10	Bangkok, Thailand (BANGK) (10)	10.0	12.5	100.0	102.5	1	L	Asia	TROPICAL
11	Cape Town, South Africa (CAPTOW) (11)	-35.0	-32.5	17.5	20.0	1	LW	Africa	SUBTROPICAL
12	Washington, D.C. (DC) (12)	35.0	40.0	280.0	285.0	4	L	North America	TEMPERATE
13	East Congo, Zaire (ECONGO) (13)	-7.5	5.0	27.5	30.0	5	M	Africa	TROPICAL
14	Greenland (GRNLHI) (14)	67.5	70.0	320.0	325.0	2	M	Greenland	POLAR
15	Hawaii Area (HAWAII) (15)	17.5	22.5	200.0	205.0	4	W	Asia	TROPICAL
16	Huancayo, Peru (HUANCO) (16)	-12.5	-10.0	285.0	287.5	1	M	South America	TROPICAL
17	Indian Ocean, Diego Garcia (INDOC) (17)	-10.0	-5.0	287.5	292.5	4	W	Asia	TROPICAL
18	Irkutsk, Siberia (IRKTSK) (18)	50.0	55.0	97.5	102.5	4	M	Asia	BOREAL
19	Lower Sea of Japan (JAPSEA) (19)	32.5	40.0	125.0	137.5	15	LW	Asia	TEMPERATE
20	Kabul, Afghanistan (KABUL) (20)	32.5	35.0	65.0	67.5	1	M	Asia	SUBTROPICAL
21	Kashmir, India (KASHMR) (21)	32.5	35.0	75.0	77.5	1	M	Asia	TEMPERATE
22	LaPaz, Bolivia (LAPAZ) (22)	-20.0	-15.0	290.0	292.5	2	M	South America	TROPICAL
23	Lhasa, Tibet, Himalayas (LHASA) (23)	30.0	32.5	90.0	92.5	1	M	Asia	TEMPERATE
24	Manaus, Brazil, Amazon Forest (MANAUS) (24)	-5.0	-2.5	297.5	300.0	1	L	South America	TROPICAL
25	Manila, Philippines (MANILA) (25)	12.5	15.0	120.0	122.5	1	LW	Asia	TROPICAL
26	Miami, Florida (MIA) (26)	25.0	27.5	277.5	280.0	1	L	North America	SUBTROPICAL
27	Northwest Africa, Morocco (MOR) (27)	30.0	37.5	352.5	357.5	6	LW	Africa	SUBTROPICAL
28	Moscow, Russia (MOSCOW) (28)	55.0	57.5	37.5	40.0	1	L	Europe	TEMPERATE
29	Alaska (NAK) (29)	45.0	60.0	170.0	195.0	60	LW	North America	BOREAL
30	Tanami Desert, Australlia (NAUS) (30)	-25.0	-15.0	130.0	137.5	12	L	Australia	TROPICAL
31	New Guinea (NGUIN) (31)	-5.0	-2.5	140.0	142.5	1	M	WATER/Pac	TROPICAL
32	Prince Edward Island, Canada (PEILSE) (32)	45.0	47.5	295.0	297.5	1	LW	North America	TEMPERATE
33	Portland, Oregon (PORT) (33)	45.0	47.5	235.0	237.5	1	L	North America	TEMPERATE
34	Pyrenee Mountains (PYRNES) (34)	42.5	45.0	357.5	2.5	2	M	Europe	SUBTROPICAL
35	Quito, Ecuador (QUITO) (35)	0.0	2.5	282.5	285.0	1	M	South America	TROPICAL
36	Santiago, Chile (SANTGO) (36)	-32.5	-30.0	287.5	290.0	1	M	South America	SUBTROPICAL
37	Spokane, Washington (SPOK) (37)	47.5	50.0	240.0	242.5	1	M	North America	TEMPERATE
38	Tangmai, Tibet (TANGMI) (38)	27.5	30.0	92.5	100.0	3	M	Asia	TEMPERATE
39	Tehran, Iran (TEHRAN) (39)	32.5	35.0	50.0	52.5	1	M	Asia	SUBTROPICAL
40	Tucson, Arizona (TUCS) (40)	30.0	32.5	247.5	250.0	1	L	North America	SUBTROPICAL
41	Ural Mountains (URALS) (41)	57.5	62.5	57.5	62.5	4	M	Europe	BOREAL
42	Xining, China (XINING) (42)	35.0	37.5	102.5	105.0	1	M	Asia	TEMPERATE
43	New Caledonia (NEWCAL) (43)	-20.0	-17.5	165.0	167.5	1	LW	Asia	TROPICAL
44	New Zealand (NEWZEA) (44)	-45.0	-42.5	170.0	172.5	1	LW	Asia	TEMPERATE
45	Rio de Janerio (RIODEJ) (45)	-25.0	-22.5	315.0	317.5	1	LW	South America	TROPICAL
46	Falklands (FALKLD) (46)	-52.5	-50.0	300.0	302.5	1	LW	South America	TEMPERATE

Table 3 — Monthly Surface Refractivity (N) for 46 Areas of Intrest from ECM Surface Data

AOI	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Ahaggar, Algeria (AHAGR) (1)	302.77	289.42	293.71	296.08	298.16	305.12	310.96	315.93	310.12	304.35	302.11	297.66
Bering Sea (AK) (2)	309.34	310.64	312.34	316.49	318.38	321.63	326.67	332.02	329.17	322.59	316.12	311.38
Albuquerque, New Mexico (ALBQ) (3)	313.65	313.86	305.36	306.30	313.98	322.25	351.37	364.77	349.65	331.85	317.12	318.27
Alberta, Canada (ALBRTA) (4)	314.61	315.31	325.51	320.27	332.05	336.21	344.84	343.59	336.72	327.38	318.92	316.76
Alp Mountains (ALPS) (5)	321.14	322.99	325.02	330.92	342.28	353.07	362.66	357.04	356.01	344.34	330.94	324.26
Amazon Forest (AMFOR) (6)	383.90	380.73	382.27	387.87	391.70	394.22	391.90	392.72	392.84	394.01	393.83	388.15
Aquas, Mexico (AQUAS) (7)	339.64	333.15	322.45	329.25	336.61	369.05	384.45	384.54	384.11	366.41	355.79	346.67
Greenland, Iceland, UK (ATL50) (8)	317.48	316.95	317.34	322.56	324.82	330.44	335.11	335.73	330.40	323.85	321.20	317.50
Baghdad, Iraq (BAGDAD) (9)	317.26	314.59	317.80	327.31	320.49	313.55	310.95	311.25	308.62	311.91	319.27	321.10
Bangkok, Thailand (BANGK) (10)	379.69	386.43	392.48	397.98	396.62	396.42	389.19	390.52	391.10	390.95	391.33	379.24
Cape Town, South Africa (CAPTOW) (11)	349.98	350.38	351.34	347.25	346.61	340.19	337.64	341.71	340.96	344.65	346.75	347.83
Washington, D.C. (DC) (12)	314.70	317.30	321.45	329.90	346.58	366.61	380.96	380.73	365.36	341.67	331.81	317.24
East Congo, Zaire (ECONGO) (13)	385.35	393.31	400.09	402.53	396.38	385.52	380.09	378.20	385.04	393.76	399.01	394.94
Greenland (GRNLHI) (14)	305.04	305.44	305.97	307.32	314.35	318.32	320.59	319.08	310.61	305.85	306.60	305.14
Hawaii Area (HAWAII) (15)	370.76	370.49	373.74	373.94	374.51	375.84	380.01	382.59	381.75	382.05	381.10	374.95
Huancayo, Peru (HUANCO) (16)	384.17	383.43	383.65	393.20	386.72	388.12	378.75	372.25	378.50	384.77	378.12	384.38
Indian Ocean, Diego Garcia (INDOC) (17)	390.53	390.53	391.73	392.13	389.33	381.91	375.53	380.27	386.39	389.09	391.82	392.65
Irkutsk, Siberia (IRKTSK) (18)	316.12	315.82	313.49	326.47	329.37	343.34	356.91	350.39	335.73	321.34	316.48	316.41
Lower Sea of Japan (JAPSEA) (19)	316.61	316.13	318.40	330.00	341.45	359.09	380.95	386.59	364.25	341.61	328.08	319.35
Kabul, Afghanistan (KABUL) (20)	318.67	320.70	328.49	324.33	316.61	303.79	310.89	312.52	296.26	302.42	313.09	322.36
Kashmir, India (KASHMR) (21)	327.37	329.08	335.29	341.54	341.51	351.66	383.41	392.73	375.43	346.54	330.22	331.30
LaPaz, Bolivia (LAPAZ) (22)	356.17	361.50	364.97	359.65	349.83	345.20	342.86	344.93	346.87	354.35	350.83	358.43
Lhasa, Tibet, Himalayas (LHASA) (23)	313.95	314.71	321.85	330.41	342.29	346.82	362.94	363.62	359.67	338.72	320.14	319.21
Manaus, Brazil, Amazon Forest (MANAUS) (24)	394.22	394.00	394.25	392.32	392.79	393.89	386.15	384.22	391.81	390.69	390.53	392.47
Manila, Philippines (MANILA) (25)	387.40	380.95	388.25	391.51	389.89	396.58	397.06	390.22	398.73	397.51	397.94	385.32
Miami, Florida (MIA) (26)	376.86	376.46	377.61	382.29	387.39	395.39	396.95	395.47	394.01	390.43	387.08	381.19
Northwest Africa, Morocco (MOR) (27)	332.40	333.08	333.54	332.55	339.60	350.28	355.06	355.69	354.12	348.09	343.32	336.36
Moscow, Russia (MOSCOW) (28)	312.70	315.09	315.18	317.73	326.69	344.14	346.51	339.28	330.61	321.62	315.06	313.97
Alaska (NAK) (29)	309.45	310.89	312.87	317.01	318.83	321.98	327.26	332.43	329.29	322.82	316.39	311.64
Tanami Desert, Australlia (NAUS) (30)	340.46	344.46	339.37	325.58	320.96	318.14	313.41	310.24	306.09	314.04	327.55	337.62
New Guinea (NGUIN) (31)	400.93	401.00	401.26	410.05	410.29	410.60	402.66	402.66	410.69	409.00	408.39	408.25
Prince Edward Island, Canada (PEILSE) (32)	312.21	312.94	311.86	318.12	325.19	335.97	345.24	351.89	338.39	328.05	319.04	313.31
Portland, Oregon (PORT) (33)	323.16	327.74	325.82	326.04	331.48	335.90	342.71	345.17	340.42	335.20	329.78	326.84
Pyrenee Mountains (PYRNES) (34)	328.98	327.16	330.39	333.60	339.67	355.14	365.62	362.59	356.55	344.80	336.05	329.78
Quito, Ecuador (QUITO) (35)	389.11	389.13	396.42	396.75	398.62	392.55	383.46	391.04	390.03	397.11	396.77	396.52
Santiago, Chile (SANTGO) (36)	339.44	337.91	339.47	328.80	329.03	323.71	323.32	323.83	324.51	326.04	330.52	334.62
Spokane, Washington (SPOK) (37)	320.97	320.09	320.53	326.53	332.25	339.71	335.36	334.04	327.65	327.36	322.30	320.90
Tangmai, Tibet (TANGMI) (38)	335.33	340.09	349.17	370.17	380.34	388.03	391.42	389.37	390.54	377.36	352.40	343.16
Tehran, Iran (TEHRAN) (39)	328.20	327.80	333.41	340.54	337.07	314.34	310.53	302.12	302.99	314.97	327.96	330.29
Tucson, Arizona (TUCS) (40)	318.55	316.70	314.86	321.19	330.39	349.85	364.74	369.54	360.01	337.47	328.71	325.57
Ural Mountains (URALS) (41)	315.73	316.99	314.58	313.92	319.88	337.86	347.80	339.31	327.37	316.41	314.31	314.11
Xining, China (XINING) (42)	314.07	318.10	324.83	334.79	356.14	363.28	368.50	363.35	366.67	349.51	329.35	317.73
New Caledonia (NEWCAL) (43)	385.17	384.21	385.84	382.43	379.53	368.38	365.00	365.13	365.68	368.36	370.74	379.92
New Zealand (NEWZEA) (44)	341.35	342.33	340.19	336.00	331.38	328.22	325.78	326.38	328.79	329.78	331.81	338.26
Rio de Janerio (RIODEJ) (45)	386.33	393.94	387.72	376.80	373.51	365.06	361.53	360.41	360.12	362.73	370.81	381.95
Falklands (FALKLD) (46)	319.15	319.51	319.75	318.13	316.64	313.40	314.89	315.08	316.77	315.98	314.66	316.10

the surface refractivity is derived from extrapolation of the original raw data supplied by the originator. Table 4 shows monthly temperature distribution for 46 AOIs of ECM surface data. Tables 5 and 6 present monthly surface relative humidity and surface pressure, respectively, for 46 AOIs of ECM surface data.

Figures 7 and 8 show the ECM surface relative humidity worldwide contour map monthly 10-year averages for February and August, respectively, to present the contrast between the coldest and hottest months of the year. Figures 9 and 10 present ECM surface refractivity worldwide contour maps for February and August monthly 10-year averages, respectively. High refractivity areas slowly move to the Northern Hemisphere with low refractivity areas noticeably in the Northern Hemisphere. Figures 11 and 12 present HIRAS surface average refractivity worldwide contour maps for February and August, respectively. These HIRAS contour maps noticeably contrast with those of Figs. 9 and 10. ECM data are generated from 10-year monthly average climatology data while HIRAS data are generated from six hourly 9-year average empirical data.

Figure 13 through 18 present direct interrelationship among temperature, relative humidity, and refractivity for the months of February and August with three AOIs. Figures 13 and 14 show the interrelationship among meteorological parameters in the Washington, D.C. area for the month of February to represents winter season and for the month of August to represent summer season. Diurnal variations of both temperature and relative humidity are more dynamic in February than in August. This implies more variations of refractivity in February than in August. Figures 15 and 16 show the interrelationship among meteorological parameters in the neighborhood of the Aleutian Islands of Alaska (NAK). Diurnal variations of temperature and relative humidity are similar to those in the Washington, D.C. area for both February and August. Figures 17 and 18 show the interrelationship among meteorological parameters for the Amazon rain forest (AMFOR) area. Diurnal variations of both temperature and relative humidity are similar for the months of both February and August. Details for other areas are included in Appendixes A to D.

4.2. Range or Time Delay and Angle-of-arrival Errors

Time delays and angle-of-arrival errors based on empirical databases and selected models appear in Tables 7 through 11. Table 7 provides time delays for HIRAS empirical data and six other models from the horizon to the elevation angle of 20°. The variation of time delays on seven different cases is noticeable. Results of Table 7 indicate that the choice of model dominates the performance of range errors and time delays. Table 7 also shows that time delay differences are minimal above the 20° elevation angle in comparison with those of lower elevation angles. Table 12 tabulates characteristics of selected models with given weather and geographical parameters and newly calculated refractivity related parameters. Some models do not provide all three of the outputs of time delay, range error, and angle-of-arrival error. Figures 19 through 22 present time delays and angle-of-arrival errors for different models with empirical data of February, May, August, and November in the Amazon rain forest. Time delay performance of the exponential model is close to the empirical data (stratified model) within 2% of sum-squared errors with empirical data while Hopfield, Goad, and Cain's model performances are worse with 20% to 30% sum squared errors; Blake model's performance is within 10% sum squared error. Angle-of-arrival error for the exponential model is worse than that of stratified model below 1° elevation angle with 20% while the angle error of the Goad and Blake models is worse than that of the stratified model with 70% sum squared error below 1° elevation angle. It is noted in these figures that both time delays and angle-of-arrival errors are at least 50 ns higher than other areas all year around for time delays and 0.2°-0.3° elevation angle errors when compared with other worldwide areas. These imply that RF wave bending or time delay depends highly on both temperature and humidity since both temperature and humidity are always high in the rain forest. Figures for other AOIs are included in Appendixes E to J for a complete picture of the different geolocation and climatology.

Table 4 — Monthly Temperature (°k) for 46 Areas of Interest from ECM Surface Data

AOI	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Ahaggar, Algeria (AHAGR) (1)	295.13	297.88	301.68	306.54	309.38	312.48	313.69	312.58	311.79	307.92	301.93	297.23
Bering Sea (AK) (2)	272.97	272.96	273.35	274.52	276.16	278.09	280.47	283.07	282.63	280.46	277.15	274.96
Albuquerque, New Mexico (ALBQ) (3)	289.01	290.80	292.65	296.58	300.56	306.52	307.73	306.76	304.76	299.83	294.01	290.23
Alberta, Canada (ALBRTA) (4)	275.72	275.34	278.06	280.95	286.87	291.30	293.87	294.81	289.91	285.50	278.59	275.42
Alp Mountains (ALPS) (5)	280.68	281.17	283.54	286.49	290.46	294.57	298.58	297.97	295.75	290.76	285.24	282.69
Amazon Forest (AMFOR) (6)	298.17	298.34	298.75	298.99	299.20	299.15	299.29	299.54	299.68	299.81	299.63	298.87
Aquas, Mexico (AQUAS) (7)	296.66	297.57	299.53	300.39	301.41	302.56	301.63	301.63	301.77	300.81	299.81	299.06
Greenland, Iceland, UK (ATL50) (8)	278.13	277.81	277.55	278.89	280.14	282.12	283.69	284.55	284.01	281.85	280.36	279.21
Baghdad, Iraq (BAGDAD) (9)	286.01	287.97	291.90	298.82	303.53	308.32	313.16	313.23	310.56	302.88	294.14	288.20
Bangkok, Thailand (BANGK) (10)	299.73	299.68	300.64	301.56	301.54	301.63	301.63	300.55	300.60	300.62	300.77	299.88
Cape Town, South Africa (CAPTOW) (11)	292.69	292.54	292.72	291.90	289.73	289.01	288.05	288.02	288.01	288.84	289.62	291.71
Washington, D.C. (DC) (12)	277.21	279.65	284.18	288.94	293.73	297.90	299.75	299.26	296.05	290.25	285.46	279.84
East Congo, Zaire (ECONGO) (13)	301.60	302.16	302.52	302.32	301.77	301.22	301.73	303.09	303.67	303.61	303.08	302.49
Greenland (GRNLHI) (14)	264.86	264.38	264.50	268.77	275.26	280.72	282.68	281.77	275.89	270.70	268.21	265.00
Hawaii Area (HAWAII) (15)	296.98	297.02	296.85	296.84	297.25	298.06	298.50	298.95	298.82	298.90	298.44	298.00
Huancayo, Peru (HUANCO) (16)	297.76	297.76	297.78	296.86	296.84	296.87	298.06	298.03	298.02	298.04	297.79	297.77
Indian Ocean, Diego Garcia (INDOC) (17)	298.54	298.53	298.75	298.84	298.52	298.14	298.14	299.19	299.62	299.86	300.09	299.55
Irkutsk, Siberia (IRKTSK) (18)	264.98	264.92	270.47	278.36	286.77	292.36	295.98	294.86	289.28	280.72	272.63	267.35
Lower Sea of Japan (JAPSEA) (19)	276.87	277.23	280.38	285.47	289.65	293.80	297.47	299.33	295.73	290.43	285.21	279.80
Kabul, Afghanistan (KABUL) (20)	287.18	288.04	291.70	297.63	300.46	304.23	306.17	305.24	302.43	298.75	295.06	290.14
Kashmir, India (KASHMR) (21)	287.69	288.59	292.68	297.56	300.38	303.29	303.29	302.36	301.52	298.86	295.01	290.88
LaPaz, Bolivia (LAPAZ) (22)	296.54	297.12	297.13	296.67	296.75	296.76	296.84	296.86	297.44	297.35	297.34	297.70
Lhasa, Tibet, Himalayas (LHASA) (23)	289.02	289.89	291.91	293.95	294.77	296.62	296.51	296.56	296.76	296.33	293.41	291.38
Manaus, Brazil, Amazon Forest (MANAUS) (24)	298.58	298.56	298.48	299.71	299.61	299.77	299.79	300.85	300.67	300.66	300.63	299.67
Manila, Philippines (MANILA) (25)	299.75	299.75	299.63	301.67	301.61	301.58	301.66	300.56	300.61	301.71	301.76	300.84
Miami, Florida (MIA) (26)	297.82	298.12	298.60	299.00	299.75	300.31	300.59	300.69	300.44	300.07	299.19	298.47
Northwest Africa, Morocco (MOR) (27)	289.24	290.20	292.67	294.21	296.68	301.11	305.49	305.58	303.30	299.03	294.13	290.53
Moscow, Russia (MOSCOW) (28)	264.87	263.53	267.95	277.35	287.93	291.84	293.95	291.88	286.91	279.67	271.10	266.86
Alaska (NAK) (29)	273.51	273.34	273.87	274.84	276.46	278.33	280.53	283.13	282.66	280.47	277.48	275.58
Tanami Desert, Austrailia (NAUS) (30)	305.08	304.42	302.10	299.30	295.47	291.87	291.26	294.51	298.57	302.79	304.73	306.65
New Guinea (NGUIN) (31)	299.77	299.77	299.79	299.80	299.86	299.89	299.86	299.85	299.85	300.96	300.91	300.90
Prince Edward Island, Canada (PEILSE) (32)	266.22	267.23	270.19	276.27	282.25	287.46	290.48	290.70	287.81	281.68	276.50	269.36
Portland, Oregon (PORT) (33)	282.76	281.71	282.96	284.09	285.00	286.65	288.49	289.47	289.77	287.79	284.96	282.76
Pyrenee Mountains (PYRNES) (34)	282.72	283.12	285.72	288.02	291.13	295.75	298.60	298.58	297.26	292.13	287.10	284.17
Quito, Ecuador (QUITO) (35)	298.78	298.78	298.78	298.80	297.68	297.92	299.05	298.85	298.84	298.82	298.79	298.99
Santiago, Chile (SANTGO) (36)	293.20	294.36	293.37	292.49	289.73	288.78	288.94	288.75	288.74	289.59	291.55	293.38
Spokane, Washington (SPOK) (37)	276.54	279.05	281.94	284.92	288.88	292.81	296.97	297.74	292.90	287.93	280.95	276.82
Tangmai, Tibet (TANGMI) (38)	290.26	291.17	293.41	295.43	296.93	298.14	299.19	299.22	298.34	297.61	294.47	291.76
Tehran, Iran (TEHRAN) (39)	287.17	287.10	290.93	295.72	298.40	302.25	305.31	304.33	302.58	298.86	294.13	289.20
Tucson, Arizona (TUCS) (40)	292.94	293.83	294.77	297.66	299.50	303.36	305.44	306.49	304.51	301.77	295.71	292.78
Ural Mountains (URALS) (41)	258.41	258.70	264.21	273.21	281.89	290.79	292.95	289.76	283.79	275.49	265.32	261.70
Xining, China (XINING) (42)	283.18	284.95	288.79	292.78	294.65	296.58	296.48	296.53	296.95	294.24	288.11	285.10
New Caledonia (NEWCAL) (43)	299.63	299.48	299.70	298.81	296.77	295.83	294.94	295.11	294.91	295.79	296.67	298.68
New Zealand (NEWZEA) (44)	289.69	289.98	289.13	287.11	283.86	282.90	281.84	281.93	283.66	285.76	287.79	288.81
Rio de Janerio (RIODEJ) (45)	299.56	300.71	299.77	298.84	296.95	295.11	293.99	293.72	293.70	294.63	296.68	297.59
Falklands (FALKLD) (46)	282.10	282.14	280.23	279.24	278.24	277.31	276.33	276.35	277.40	277.28	279.13	280.13

Table 5 — Monthly Relative Humidity (%) for 46 Areas of Interest from ECM Surface Data

AOI	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Ahaggar, Algeria (AHAGR) (1)	30.65	18.45	20.42	19.48	18.95	19.88	21.13	23.48	22.12	22.28	25.12	24.62
Bering Sea (AK) (2)	83.82	86.02	87.33	91.27	91.53	93.46	93.77	94.00	91.82	87.91	86.15	84.23
Albuquerque, New Mexico (ALBQ) (3)	48.51	46.87	36.41	33.26	34.56	31.99	43.66	51.73	48.13	46.75	45.29	52.03
Alberta, Canada (ALBRTA) (4)	76.48	79.50	85.13	78.16	80.08	70.91	71.34	67.53	75.48	77.16	82.81	82.20
Alp Mountains (ALPS) (5)	79.32	82.51	79.78	80.19	80.59	76.80	71.21	68.93	75.10	80.65	82.81	79.38
Amazon Forest (AMFOR) (6)	88.42	86.08	85.87	88.89	90.42	92.05	90.06	89.67	89.28	89.59	90.21	89.30
Aquas, Mexico (AQUAS) (7)	58.61	51.87	40.96	44.31	47.21	64.13	75.64	75.84	75.00	66.83	62.42	57.71
Greenland, Iceland, UK (ATL50) (8)	87.15	86.98	87.40	91.08	91.62	94.35	95.56	94.30	89.73	87.28	87.42	85.67
Baghdad, Iraq (BAGDAD) (9)	59.26	52.94	50.35	46.35	35.19	26.90	22.20	22.14	22.70	30.46	46.25	60.01
Bangkok, Thailand (BANGK) (10)	80.26	85.37	86.02	86.01	85.18	84.68	80.21	85.17	85.25	84.77	84.19	79.25
Cape Town, South Africa (CAPTOW) (11)	81.12	82.20	82.69	81.02	88.74	82.94	82.86	88.85	88.24	89.62	89.04	83.03
Washington, D.C. (DC) (12)	73.79	73.96	71.76	71.31	73.88	76.54	80.14	81.95	81.86	79.53	82.99	72.37
East Congo, Zaire (ECONGO) (13)	77.46	80.61	83.12	85.27	83.22	78.24	73.37	68.97	71.32	76.18	80.47	80.12
Greenland (GRNLHI) (14)	60.68	60.82	60.79	64.11	79.37	76.95	76.89	76.82	70.12	62.07	63.83	58.34
Hawaii Area (HAWAII) (15)	84.04	83.75	86.69	87.03	85.67	83.23	84.79	85.10	84.87	84.97	86.00	83.22
Huancayo, Peru (HUANCO) (16)	90.08	89.25	89.25	94.18	95.47	96.53	84.01	79.55	84.29	88.99	85.35	90.10
Indian Ocean, Diego Garcia (INDOC) (17)	92.77	92.80	92.71	92.59	91.80	87.50	82.80	82.32	85.25	86.35	87.46	90.21
Irkutsk, Siberia (IRKTSK) (18)	73.17	73.00	70.69	91.57	76.79	76.29	77.03	74.62	75.85	76.69	77.34	77.34
Lower Sea of Japan (JAPSEA) (19)	77.72	76.44	74.34	81.50	83.09	86.66	90.46	87.16	83.31	79.58	78.10	77.08
Kabul, Afghanistan (KABUL) (20)	58.02	60.21	61.48	45.78	36.58	25.85	28.09	29.63	22.16	27.68	39.41	56.93
Kashmir, India (KASHMR) (21)	69.58	70.14	66.21	59.49	53.28	53.77	71.78	80.10	71.68	59.05	54.69	65.42
LaPaz, Bolivia (LAPAZ) (22)	72.84	75.41	78.16	74.96	66.77	62.90	60.80	62.26	62.43	68.60	65.99	71.02
Lhasa, Tibet, Himalayas (LHASA) (23)	49.40	49.72	53.62	57.49	66.56	65.91	79.32	79.33	75.03	58.17	47.08	49.97
Manaus, Brazil, Amazon Forest (MANAUS) (24)	95.27	95.36	95.84	88.97	89.62	89.51	83.98	78.82	84.80	84.07	84.21	89.60
Manila, Philippines (MANILA) (25)	85.51	81.44	86.90	81.30	80.51	84.75	84.87	84.74	90.08	84.78	84.68	80.10
Miami, Florida (MIA) (26)	84.86	83.62	82.84	84.96	85.34	88.73	88.61	87.32	87.35	86.30	87.36	85.68
Northwest Africa, Morocco (MOR) (27)	71.47	70.39	65.55	62.62	62.32	59.64	52.93	52.91	56.00	61.24	69.74	72.70
Moscow, Russia (MOSCOW) (28)	87.55	89.18	90.43	83.89	69.38	79.00	74.17	73.06	78.58	84.22	89.23	95.09
Alaska (NAK) (29)	83.47	85.86	87.86	91.89	91.95	93.41	94.22	94.10	92.13	88.29	86.08	83.96
Tanami Desert, Austrailia (NAUS) (30)	43.79	47.05	47.61	42.91	45.71	49.70	45.86	37.84	30.34	31.37	36.76	39.50
New Guinea (NGUIN) (31)	94.39	94.39	94.38	89.86	96.12	89.97	95.07	95.07	90.77	94.41	94.24	94.25
Prince Edward Island, Canada (PEILSE) (32)	88.61	89.05	83.01	89.58	84.67	84.27	83.85	90.62	85.20	91.44	90.60	89.03
Portland, Oregon (PORT) (33)	77.99	91.39	84.09	80.29	85.27	85.10	87.14	86.80	80.51	81.05	83.44	85.09
Pyrenee Mountains (PYRNES) (34)	86.62	83.16	80.28	78.60	74.77	74.30	73.05	71.00	70.25	76.04	83.50	83.22
Quito, Ecuador (QUITO) (35)	89.84	89.84	95.08	95.10	90.79	95.99	84.40	90.92	90.13	95.35	95.32	94.07
Santiago, Chile (SANTGO) (36)	68.86	64.48	68.64	60.17	67.30	62.74	62.02	62.63	63.85	63.72	64.22	63.49
Spokane, Washington (SPOK) (37)	90.37	82.37	76.59	77.87	73.69	70.13	55.37	52.93	57.68	69.75	82.57	88.83
Tangmai, Tibet (TANGMI) (38)	71.71	74.98	77.02	88.84	91.45	92.85	90.69	88.91	93.01	85.30	75.18	75.29
Tehran, Iran (TEHRAN) (39)	71.05	71.41	68.21	62.26	53.49	33.03	27.96	24.27	25.35	36.10	53.93	68.45
Tucson, Arizona (TUCS) (40)	49.29	45.94	42.88	43.75	47.43	51.95	55.18	55.18	55.02	47.37	53.22	56.61
Ural Mountains (URALS) (41)	91.85	89.54	83.37	82.78	76.01	75.48	79.19	80.83	84.48	84.50	91.99	91.37
Xining, China (XINING) (42)	58.23	63.95	64.81	65.10	79.86	79.49	84.11	79.49	79.64	72.88	69.08	60.29
New Caledonia (NEWCAL) (43)	84.95	84.87	84.72	85.86	91.59	86.40	86.96	86.53	87.81	86.29	85.07	84.61
New Zealand (NEWZEA) (44)	83.88	83.17	83.04	84.83	89.69	88.69	88.55	88.63	88.55	82.69	78.70	83.17
Rio de Janerio (RIODEJ) (45)	85.59	86.42	85.76	81.30	85.72	85.39	86.37	86.15	86.23	85.38	84.82	90.45
Falklands (FALKLD) (46)	82.25	82.32	87.94	87.85	87.65	81.90	87.61	87.86	88.11	87.85	81.89	82.04

Table 6 — Monthly Surface Pressure (mb) for 46 Areas of Interest from ECM Surface Data

AOI	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Ahaggar, Algeria (AHAGR) (1)	1018.35	1016.22	1013.17	1011.29	1010.03	1010.88	1010.65	1011.00	1012.61	1014.43	1015.96	1017.97
Bering Sea (AK) (2)	998.25	1000.90	1003.47	1011.15	1011.00	1010.83	1013.91	1012.92	1011.86	1010.35	1003.62	999.14
Albuquerque, New Mexico (ALBQ) (3)	1019.57	1016.95	1013.79	1012.96	1011.17	1010.98	1013.41	1014.11	1014.29	1015.90	1017.02	1019.19
Alberta, Canada (ALBRTA) (4)	1019.17	1019.16	1016.12	1016.32	1014.62	1013.98	1015.41	1015.02	1015.90	1016.40	1015.52	1020.64
Alp Mountains (ALPS) (5)	1020.12	1018.66	1016.15	1014.29	1014.41	1016.33	1017.44	1016.79	1018.67	1019.09	1018.96	1019.80
Amazon Forest (AMFOR) (6)	1012.95	1012.62	1012.57	1012.50	1013.06	1014.28	1014.37	1013.88	1013.32	1012.53	1012.11	1012.52
Aquas, Mexico (AQUAS) (7)	1017.41	1015.73	1013.92	1013.25	1012.57	1013.76	1016.24	1016.14	1015.81	1017.00	1016.91	1017.89
Greenland, Iceland, UK (ATL50) (8)	1005.07	1005.45	1007.40	1014.33	1014.22	1015.03	1015.57	1012.60	1009.73	1007.45	1006.77	1002.20
Baghdad, Iraq (BAGDAD) (9)	1019.51	1017.10	1013.78	1011.01	1008.06	1003.74	1000.11	1001.20	1006.49	1012.53	1017.35	1019.64
Bangkok, Thailand (BANGK) (10)	1011.48	1010.41	1009.69	1008.57	1007.73	1007.64	1008.00	1007.88	1008.79	1009.35	1010.27	1011.70
Cape Town, South Africa (CAPTOW) (11)	1014.47	1014.06	1015.15	1016.10	1016.71	1019.68	1020.46	1019.74	1018.52	1018.59	1016.83	1014.89
Washington, D.C. (DC) (12)	1019.87	1019.22	1017.12	1014.74	1015.61	1015.26	1016.48	1016.74	1018.50	1020.05	1019.67	1020.92
East Congo, Zaire (ECONGO) (13)	1010.44	1009.71	1009.40	1009.94	1010.98	1012.75	1012.70	1011.93	1010.82	1010.20	1010.40	1010.40
Greenland (GRNLHI) (14)	1004.81	1005.59	1007.57	1013.71	1016.54	1013.70	1011.27	1011.51	1013.19	1010.60	1011.15	1006.83
Hawaii Area (HAWAII) (15)	1014.69	1014.34	1016.44	1016.41	1016.13	1016.15	1015.44	1014.83	1014.07	1014.06	1014.35	1014.18
Huancayo, Peru (HUANCO) (16)	1017.46	1017.71	1018.19	1019.03	1020.03	1020.86	1020.68	1020.07	1019.84	1019.10	1018.39	1017.86
Indian Ocean, Diego Garcia (INDOC) (17)	1010.37	1010.36	1010.27	1010.81	1011.36	1012.96	1013.27	1012.39	1011.60	1010.54	1009.62	1009.66
Irkutsk, Siberia (IRKTSK) (18)	1035.04	1034.00	1028.85	1020.76	1014.79	1010.63	1007.96	1011.10	1018.24	1024.74	1031.14	1034.40
Lower Sea of Japan (JAPSEA) (19)	1022.51	1021.32	1019.08	1015.90	1012.08	1008.81	1007.79	1008.15	1013.28	1018.21	1021.30	1022.25
Kabul, Afghanistan (KABUL) (20)	1020.39	1018.65	1015.36	1012.45	1009.53	1003.34	1000.57	1002.42	1008.70	1015.59	1019.02	1020.67
Kashmir, India (KASHMR) (21)	1018.74	1016.51	1014.61	1011.22	1008.32	1003.44	1003.33	1004.72	1009.48	1014.70	1018.02	1019.12
LaPaz, Bolivia (LAPAZ) (22)	1015.17	1015.19	1015.48	1016.16	1017.21	1018.13	1018.28	1018.15	1017.90	1017.00	1016.17	1015.61
Lhasa, Tibet, Himalayas (LHASA) (23)	1019.68	1016.83	1017.22	1017.25	1016.50	1011.87	1011.75	1013.43	1016.34	1022.19	1024.85	1024.24
Manaus, Brazil, Amazon Forest (MANAUS) (24)	1010.40	1009.92	1010.16	1010.44	1011.06	1012.31	1012.55	1011.59	1010.89	1009.99	1009.55	1009.68
Manila, Philippines (MANILA) (25)	1011.90	1011.79	1011.53	1010.28	1009.07	1008.41	1008.54	1008.10	1008.98	1009.32	1010.11	1011.43
Miami, Florida (MIA) (26)	1014.23	1013.47	1013.00	1012.50	1011.84	1012.45	1013.28	1012.74	1012.07	1012.19	1012.59	1013.89
Northwest Africa, Morocco (MOR) (27)	1023.17	1019.96	1017.81	1014.73	1014.58	1015.08	1015.17	1015.04	1016.61	1017.94	1018.61	1022.40
Moscow, Russia (MOSCOW) (28)	1014.95	1021.67	1020.41	1015.19	1016.23	1011.43	1011.50	1012.15	1014.31	1018.56	1016.93	1013.79
Alaska (NAK) (29)	997.83	1000.89	1003.10	1011.20	1010.80	1010.81	1014.60	1013.59	1011.38	1010.38	1003.42	998.74
Tanami Desert, Australlia (NAUS) (30)	1007.64	1008.06	1011.55	1015.00	1017.23	1019.35	1019.85	1018.25	1015.98	1012.65	1010.19	1008.34
New Guinea (NGUIN) (31)	1012.13	1012.25	1012.71	1012.89	1013.31	1013.79	1013.91	1013.90	1013.89	1013.53	1012.72	1012.49
Prince Edward Island, Canada (PEILSE) (32)	1012.63	1014.49	1013.06	1012.92	1014.61	1012.26	1013.25	1014.80	1016.60	1017.45	1014.68	1014.06
Portland, Oregon (PORT) (33)	1017.64	1016.33	1015.23	1017.61	1018.13	1018.08	1018.63	1017.21	1016.68	1017.20	1015.26	1017.65
Pyrenee Mountains (PYRNES) (34)	1022.98	1019.98	1018.75	1015.19	1015.46	1017.70	1018.14	1017.78	1019.26	1019.32	1019.03	1021.81
Quito, Ecuador (QUITO) (35)	1015.16	1015.19	1015.17	1015.75	1016.50	1017.47	1017.74	1017.01	1016.64	1016.17	1015.57	1015.68
Santiago, Chile (SANTGO) (36)	1013.19	1012.72	1013.44	1015.01	1016.73	1018.35	1017.89	1018.74	1018.72	1017.55	1015.82	1014.16
Spokane, Washington (SPOK) (37)	1021.22	1019.22	1015.65	1016.03	1015.29	1014.63	1014.99	1013.99	1015.58	1017.73	1017.07	1021.90
Tangmai, Tibet (TANGMI) (38)	1018.98	1016.58	1015.35	1014.18	1012.70	1009.21	1009.25	1010.03	1013.75	1017.16	1020.28	1020.38
Tehran, Iran (TEHRAN) (39)	1020.12	1018.77	1016.24	1015.72	1014.39	1008.93	1006.93	1007.86	1013.27	1018.45	1020.38	1020.72
Tucson, Arizona (TUCS) (40)	1015.52	1014.30	1012.98	1011.28	1009.65	1008.51	1009.57	1009.11	1008.94	1011.33	1013.60	1015.28
Ural Mountains (URALS) (41)	1017.76	1023.30	1023.38	1015.51	1014.96	1011.95	1009.77	1010.99	1013.00	1016.35	1017.60	1016.16
Xining, China (XINING) (42)	1023.41	1018.20	1015.49	1015.34	1014.23	1011.57	1010.85	1012.50	1018.22	1021.45	1025.00	1024.82
New Caledonia (NEWCAL) (43)	1008.93	1007.90	1010.31	1012.37	1014.22	1014.52	1016.01	1016.34	1016.20	1014.62	1011.89	1009.89
New Zealand (NEWZEA) (44)	1010.14	1012.65	1014.96	1017.07	1016.04	1014.07	1013.00	1014.55	1010.09	1009.81	1010.59	1010.52
Rio de Janerio (RIODEJ) (45)	1010.69	1011.67	1012.21	1014.51	1015.80	1018.02	1019.21	1018.01	1017.33	1015.07	1012.75	1010.74
Falklands (FALKLD) (46)	999.00	1000.00	1002.05	1001.95	1001.95	1002.95	1004.06	1004.43	1005.76	1003.67	1000.00	1000.00

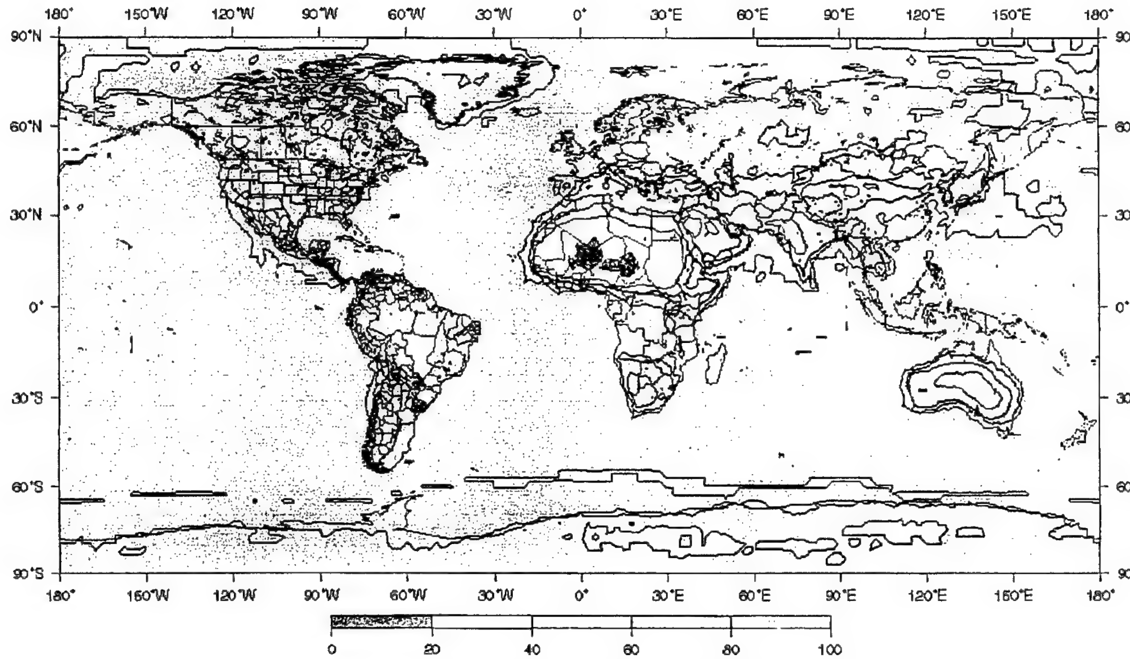


Fig. 7 — ECM surface humidity contour map for February

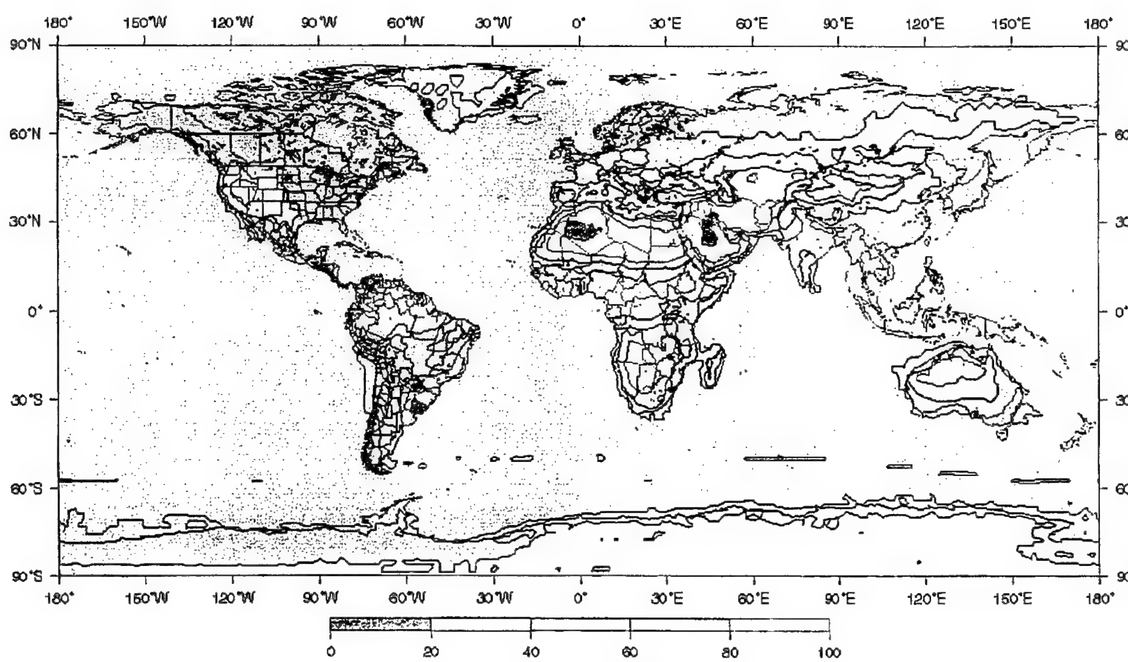


Fig. 8 — ECM surface humidity contour map for August

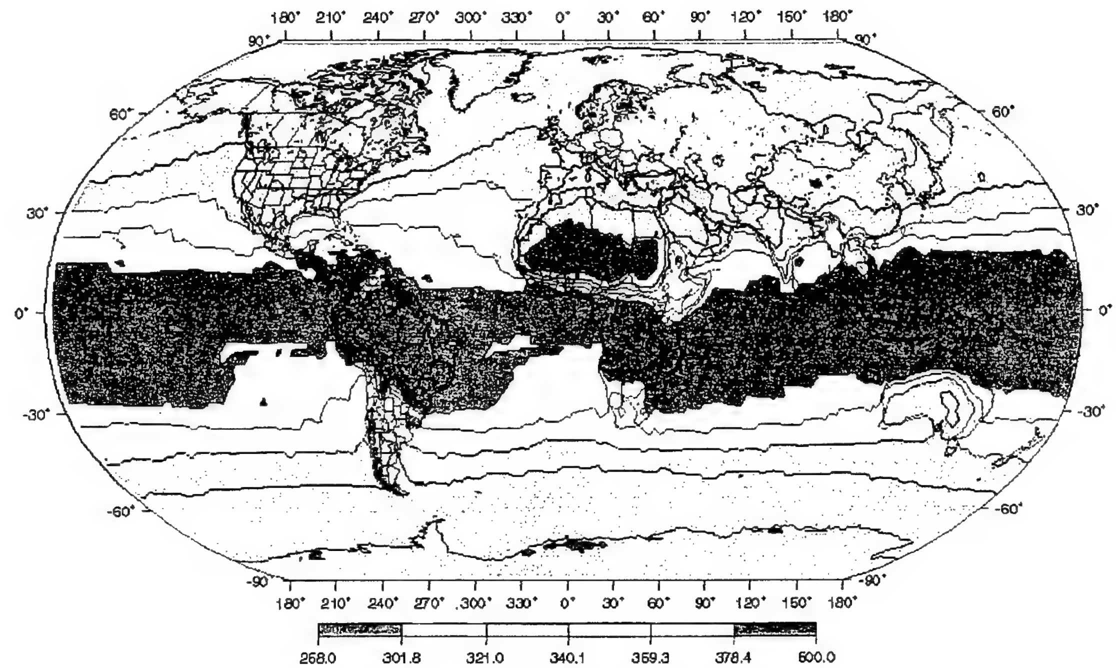


Fig. 9 — ECM refractivity data for February

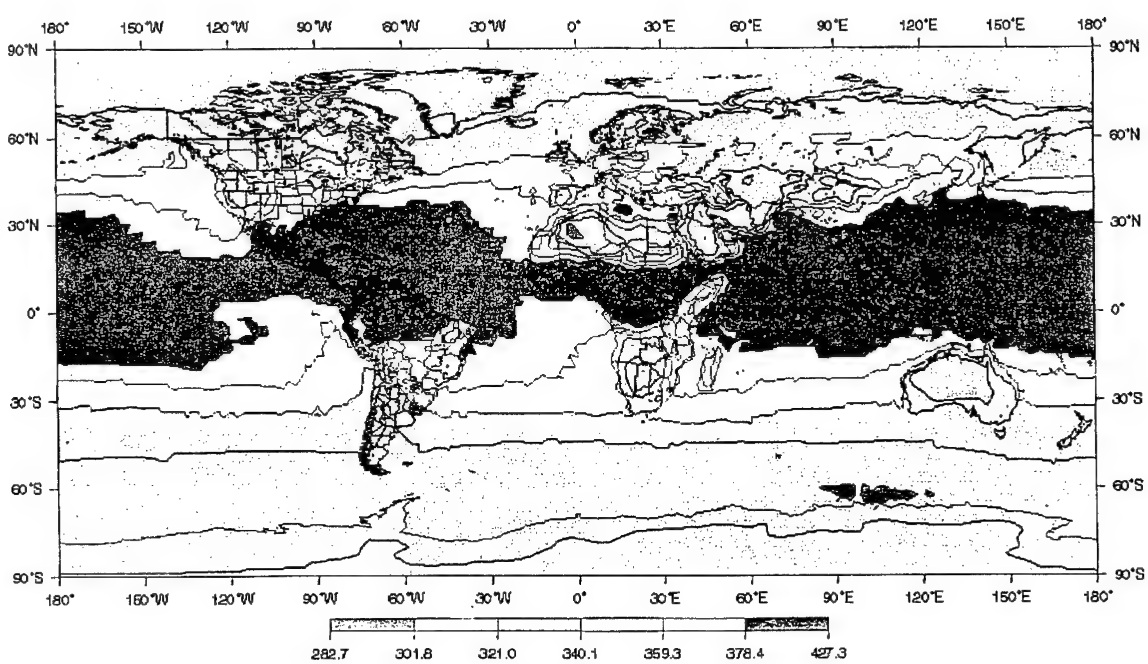


Fig. 10 — ECM surface refractivity for August

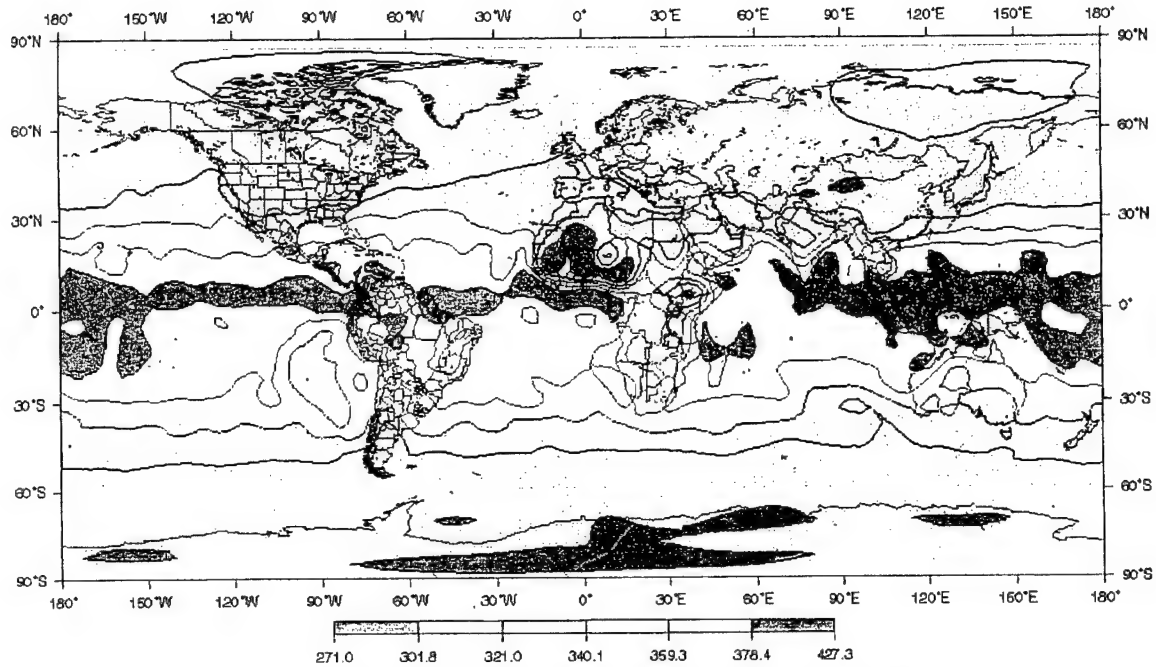


Fig. 11 — HIRAS average surface refractivity contour map for February

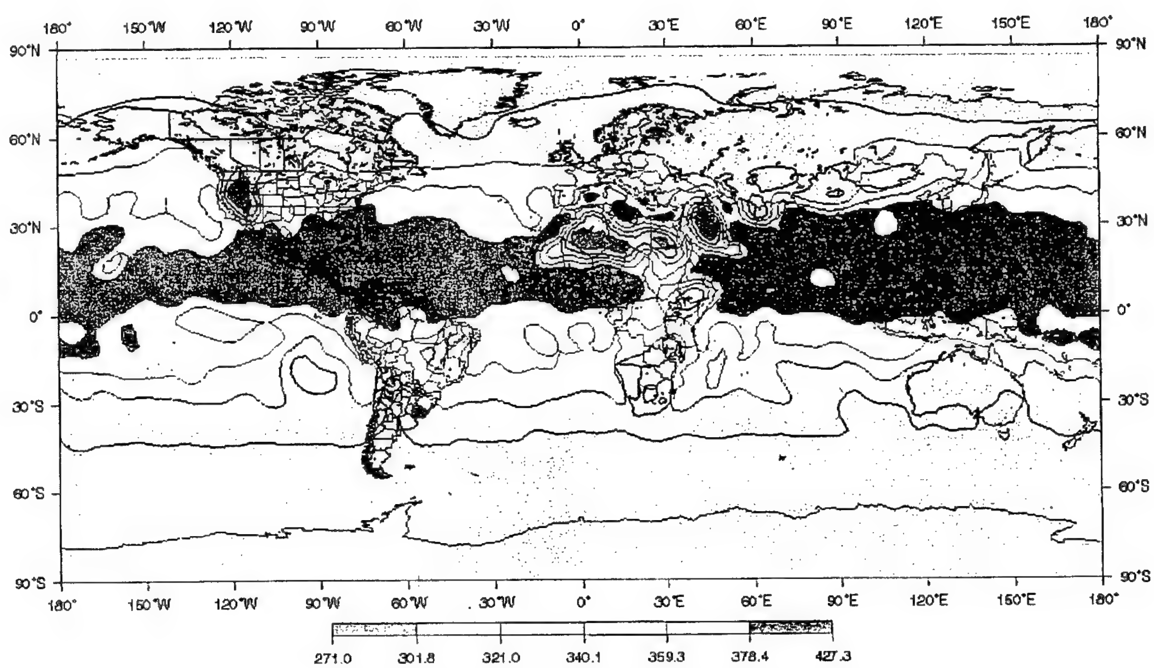


Fig. 12 — HIRAS average surface refractivity contour map for August

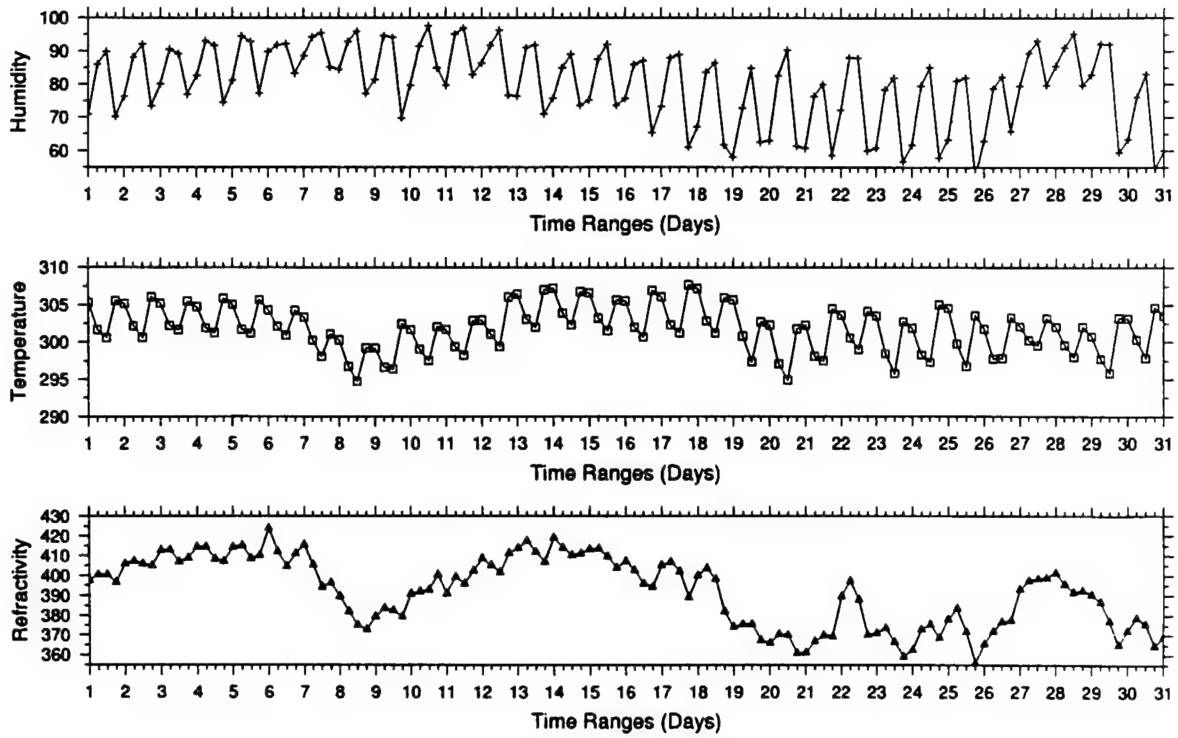


Fig. 13 — MFR time series surface data - D.C. - August 1995

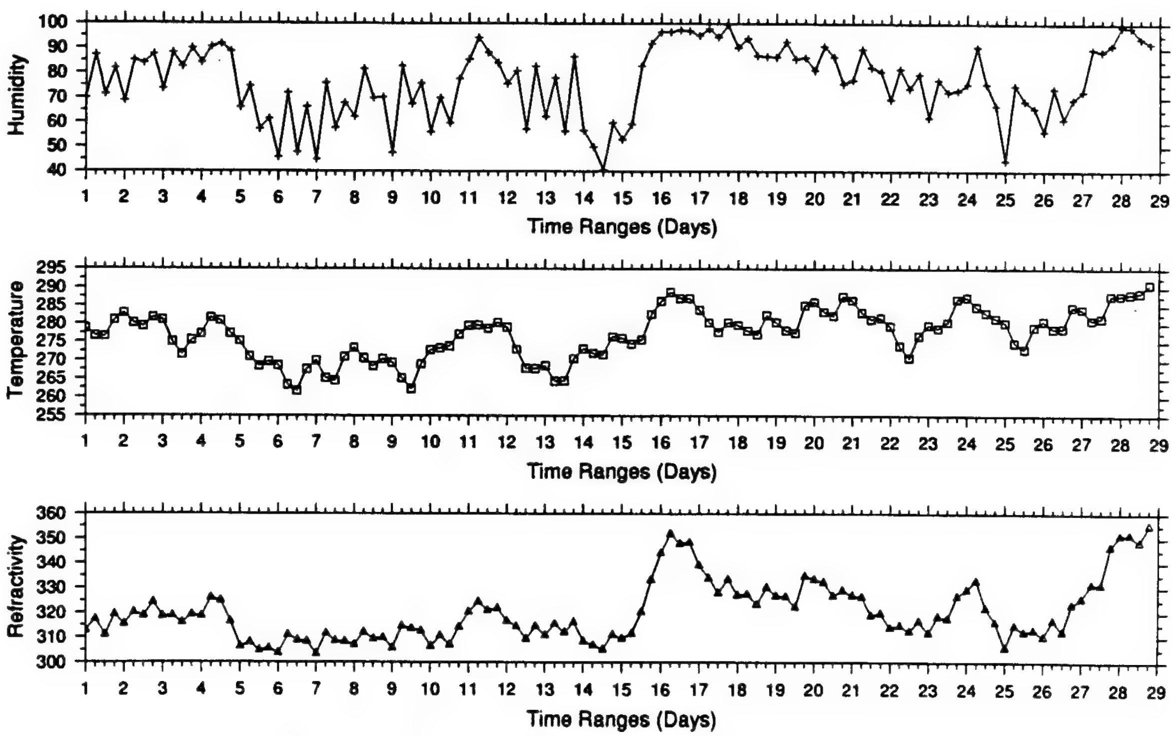


Fig. 14 — MFR time series surface data - D.C. - February1995

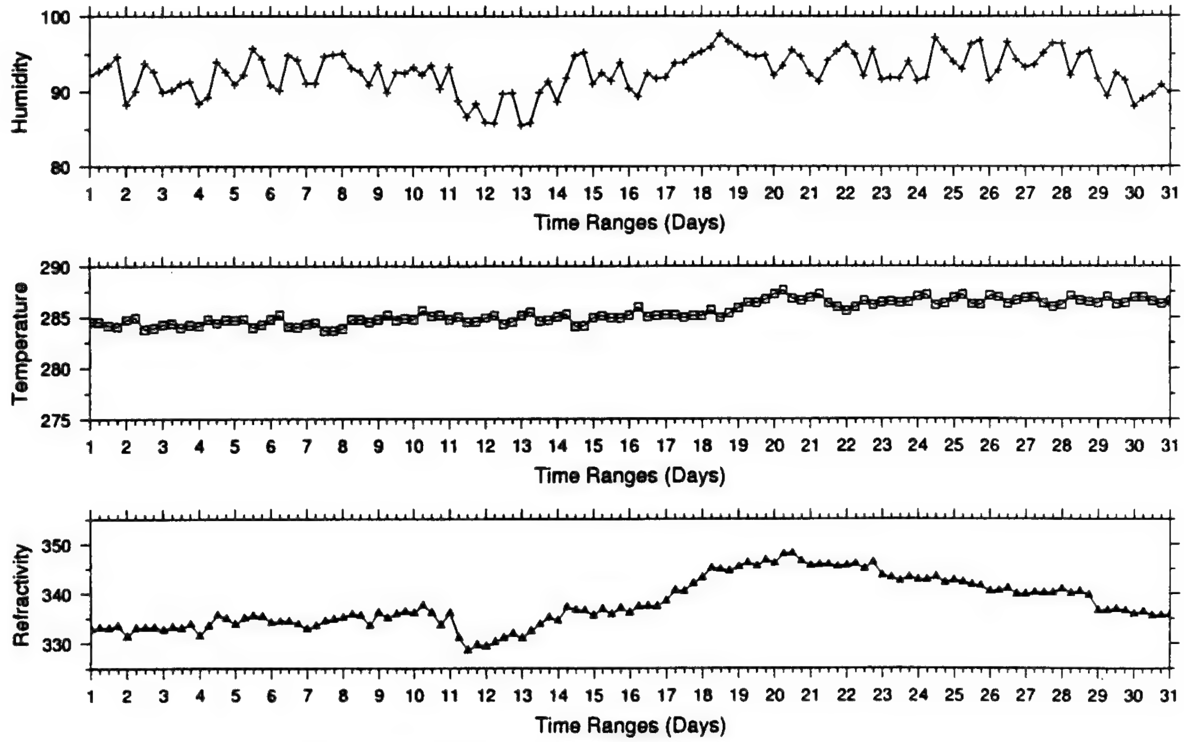


Fig. 15 — MFR time series surface data - NAK - August 1995

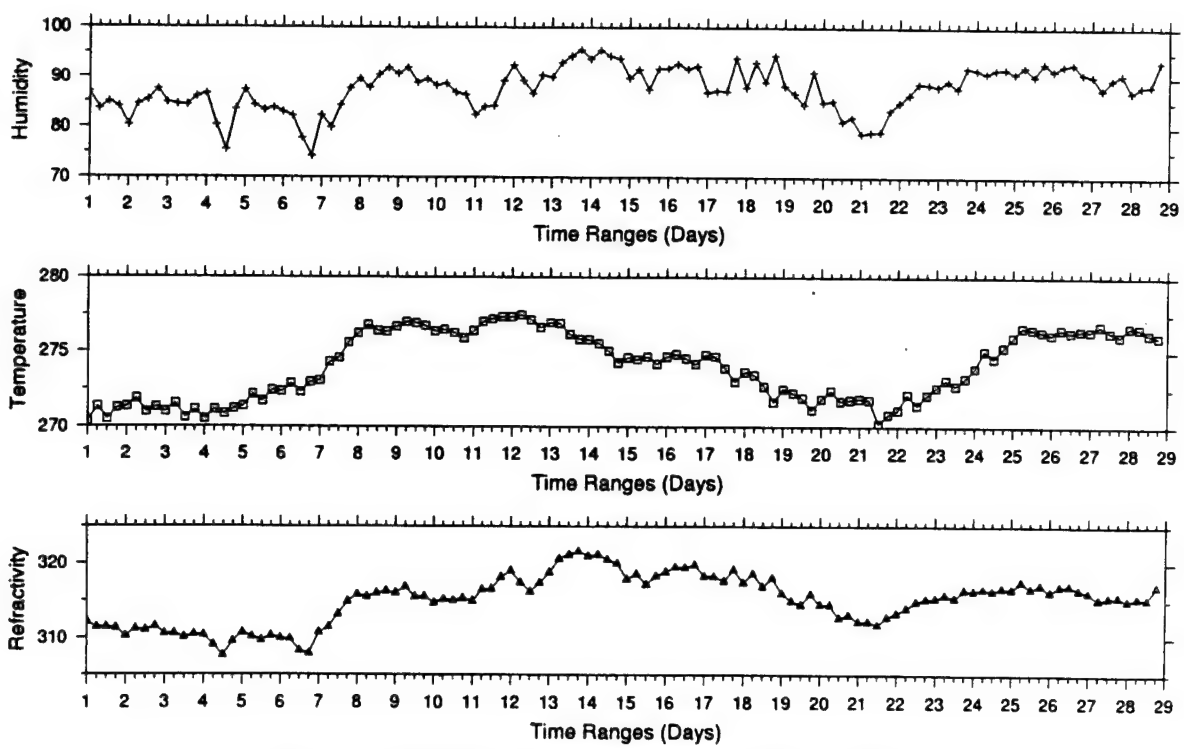


Fig. 16 — MFR time series surface data - NAK. - February1995

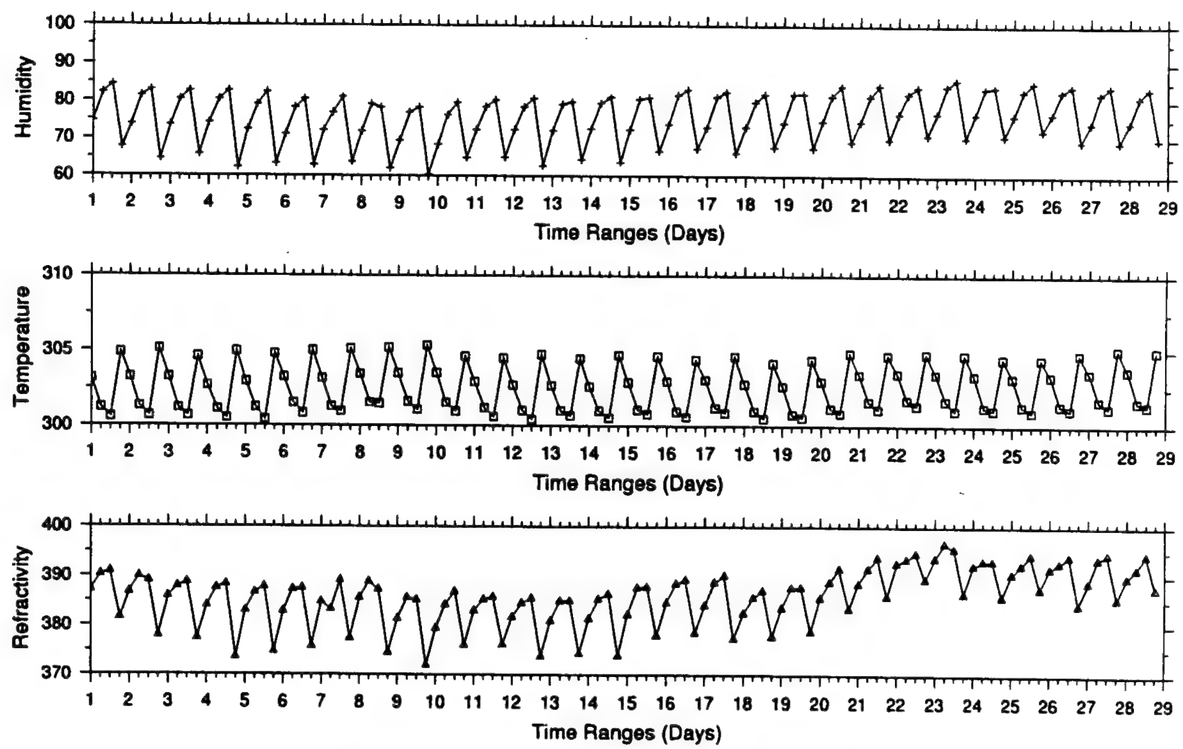


Fig. 17 — MFR time series surface data - AMFOR - February 1995

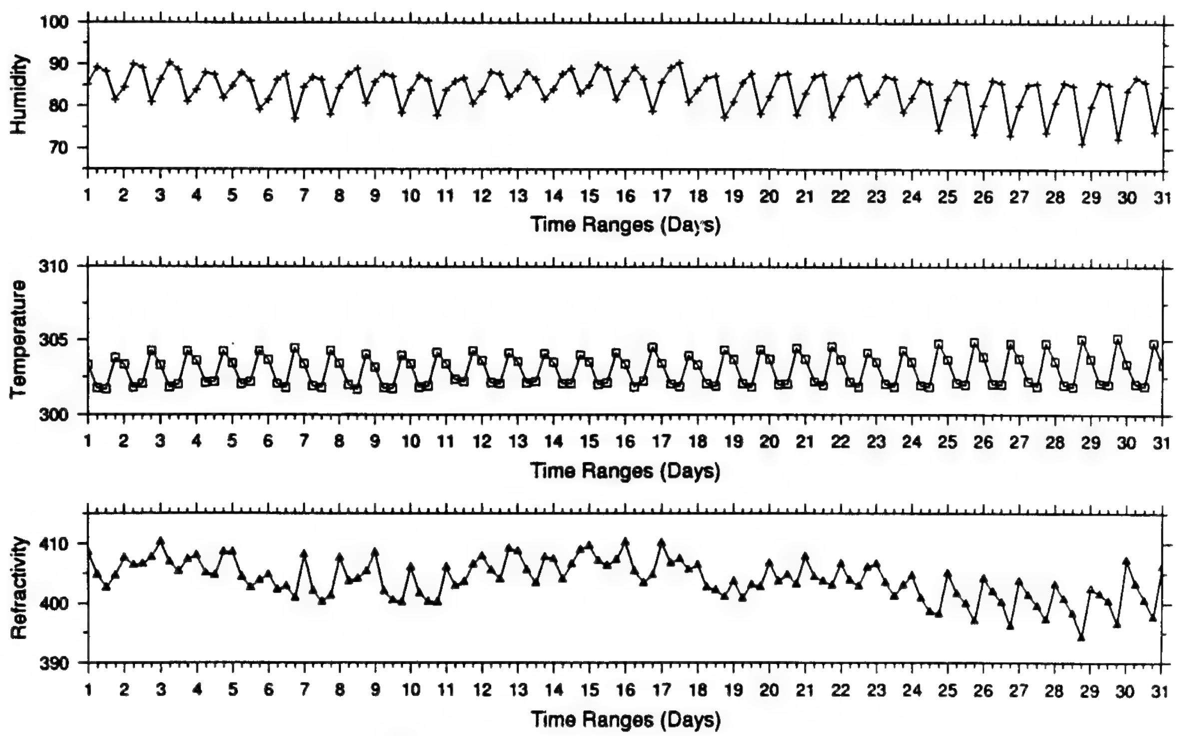


Fig. 18 — MFR time series surface data - AMFOR - August 1995

Table 7 — Time Delay for D.C. Area using HIRAS Data and Various Models

TIME DELAY: HIRAS Data DC Area June 0000Hrs

Elev Ang (deg)	Hiras Data (ns)	Hopfield (ns)	Goad (ns)	Blake (ns)	Case1 (ns)	Cains (ns)	Exponential (ns)
0.0	389.8182	303.7659	314.5687	383.8130	283.2838	305.7416	390.7063
0.1	375.4745	290.8309	301.8632	359.3598	271.6648	294.5794	373.2863
0.3	346.9649	267.8412	278.8192	318.8356	250.8466	274.2401	338.6412
0.5	320.6525	247.6968	258.5142	285.4212	232.7362	256.1953	308.7890
0.7	296.9565	229.7835	240.5303	258.3368	216.8431	240.0949	283.0852
0.9	275.6971	214.2410	224.5258	234.8224	202.7881	225.6550	260.8157
1.0	265.9126	206.8913	217.1759	224.8926	196.3543	218.9834	250.7826
2.0	192.5051	152.8345	161.4238	155.0917	147.6423	167.2969	178.5395
3.0	148.1457	119.1868	126.4661	116.7964	116.6830	133.5116	136.5358
4.0	119.3200	96.9386	103.0195	93.0177	95.3896	109.9611	109.6364
5.0	99.3956	80.9504	86.4479	76.8058	79.9267	92.7507	91.1772
7.0	74.0280	60.7560	64.9220	56.8159	59.9972	69.5410	67.7946
9.0	58.7681	48.2103	51.7582	44.9040	48.0750	54.8232	53.7809
10.0	53.2499	43.7778	46.9611	40.5902	43.7459	49.3643	48.7195
20.0	27.5687	22.6936	24.4296	20.9304	23.2593	23.3686	25.2043

TIME DELAY: HIRAS Data DC Area June 0600Hrs

Elev Ang (deg)	Hiras Data (ns)	Hopfield (ns)	Goad (ns)	Blake (ns)	Case1 (ns)	Cains (ns)	Exponential (ns)
0.0	423.5462	319.3234	331.1027	431.7951	283.2838	333.8555	427.3910
0.1	407.3434	305.1967	317.2892	399.8535	271.6648	321.6669	406.6457
0.3	374.6026	280.3016	292.3417	348.0304	250.8466	299.4574	365.0365
0.5	344.4835	258.6150	270.4740	307.1891	232.7362	279.7533	329.8315
0.7	317.5829	239.3866	251.1957	274.4678	216.8431	262.1724	300.0326
0.9	293.6434	222.8704	234.1099	247.3555	202.7881	246.4047	274.5993
1.0	282.6924	215.0168	226.2854	236.1105	196.3543	239.1196	263.2570
2.0	201.9747	158.0619	167.3688	158.5221	147.6423	182.6804	183.6426
3.0	154.4068	122.9352	130.7884	117.7930	116.6830	145.7884	138.9433
4.0	123.9192	99.8835	106.3874	93.0458	95.3896	120.0724	110.8883
5.0	103.0110	83.2629	89.1970	76.6720	79.9267	101.2794	91.8718
7.0	76.5537	62.4677	66.9249	56.4043	59.9972	75.9355	68.0338
9.0	60.7106	49.4932	53.3313	44.5259	48.0750	59.8644	53.8624
10.0	54.9925	44.9535	48.3818	40.3881	43.7459	53.9035	48.7635
20.0	28.4401	23.2768	25.1567	20.7201	23.2593	25.5174	25.1722

TIME DELAY: HIRAS Data DC Area June 1200Hrs

Elev Ang (deg)	Hiras Data (ns)	Hopfield (ns)	Goad (ns)	Blake (ns)	Case1 (ns)	Cains (ns)	Exponential (ns)
0.0	393.8191	308.0155	316.2269	389.3860	283.2838	309.3710	394.8227
0.1	379.1986	294.9406	303.3744	364.4673	271.6648	298.0763	376.9868
0.3	350.0304	271.6859	280.0761	322.1366	250.8466	277.4956	341.4725
0.5	323.1440	251:2993	259.5609	288.4410	232.7362	259.2366	310.9519
0.7	298.9896	233.1663	241.4023	260.2432	216.8431	242.9450	284.7381
0.9	277.3660	217.4202	225.2519	236.8046	202.7881	228.3337	262.0771
1.0	267.4289	209.9775	217.8382	226.3588	196.3543	221.5829	251.8829
2.0	193.1701	155.1746	161.6749	155.7803	147.6423	169.2829	178.7637
3.0	148.5149	121.0372	126.5352	116.7861	116.6830	135.0965	136.4780
4.0	119.5620	98.4517	103.0052	92.9610	95.3896	111.2664	109.4838
5.0	99.5721	82.2253	86.3953	76.8713	79.9267	93.8517	90.9956
7.0	74.1411	61.7147	64.8457	56.7520	59.9972	70.3665	67.6156
9.0	58.8514	48.9770	51.6816	44.9459	48.0750	55.4740	53.6206
10.0	53.3236	44.4731	46.8870	40.6641	43.7459	49.9503	48.5696
20.0	27.6038	23.0561	24.3822	20.9162	23.2593	23.6460	25.1181

TIME DELAY: HIRAS Data DC Area June 1800Hrs

Elev Ang (deg)	Hiras Data (ns)	Hopfield (ns)	Goad (ns)	Blake (ns)	Case1 (ns)	Cains (ns)	Exponential (ns)
0.0	372.3058	295.8059	305.4014	361.6414	283.2838	290.3725	371.9848
0.1	358.7666	283.5276	293.3031	340.7457	271.6648	279.7714	356.0563
0.3	331.9089	261.5777	271.3011	304.2218	250.8466	260.4546	324.5254
0.5	307.1603	242.2677	251.8507	274.4827	232.7362	243.3168	297.1398
0.7	284.8803	225.0627	234.5741	248.8015	216.8431	228.0258	273.3785
0.9	264.8773	210.0342	219.1602	227.6148	202.7881	214.3117	252.6510
1.0	255.6614	202.9536	212.0694	218.2405	196.3543	207.9755	243.2684
2.0	186.1647	150.3912	158.0477	152.2292	147.6423	158.8872	174.8881
3.0	143.7534	117.4784	123.9834	115.4026	116.6830	126.8002	134.4534
4.0	116.0083	95.6116	101.0679	91.8886	95.3896	104.4335	108.2989
5.0	96.7507	79.9302	84.8447	76.3979	79.9267	88.0883	90.2370
7.0	72.1484	60.0048	63.7443	56.4484	59.9972	66.0453	67.2365
9.0	57.3105	47.6595	50.8289	44.7670	48.0750	52.0674	53.3933
10.0	51.9389	43.2711	46.1207	40.5620	43.7459	46.8828	48.3858
20.0	26.9072	22.4468	23.9971	20.9486	23.2593	22.1939	25.0600

Table 8 — Time Delay (ns) for Selected Areas of Interest
MRF, Goad, and Exponential Model for 15 February 1995
(0000, 0600, 1200, and 1800 h)

	Elevation Angle = 0°															
	00 00				06 00				12 00				18 00			
AOI	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	334.0	284.9	288.8	336.3	334.0	288.8	291.1	341.4	334.0	271.8	280.8	325.1	334.0	272.6	280.9	324.2
(2) Amazon Forest (AMFOR)	431.7	330.0	338.6	424.6	430.3	329.6	337.4	423.6	430.9	329.7	337.5	423.7	431.5	330.1	339.5	424.0
(3) Bangkok, Thailand (BANGK)	430.0	329.3	338.2	418.8	415.8	321.6	331.5	408.7	421.9	325.1	334.3	413.9	425.6	326.9	336.2	416.4
(4) Washington, D.C. (DC)	337.2	294.1	291.3	341.0	340.3	295.8	292.2	343.7	350.3	299.6	296.2	351.9	362.3	302.8	302.5	363.1
(5) Alaska (NAK)	342.2	296.1	292.8	347.1	342.7	296.5	293.1	347.8	341.4	295.9	292.6	346.8	342.1	296.5	293.0	347.7
(6) Northern Australia, Tanami Desert (NAUS)	400.4	313.8	324.5	395.8	368.7	295.7	309.3	366.8	382.0	303.7	316.0	378.7	397.3	311.2	321.3	392.4
(7) Pyrenee Mountains (PYRNES)	345.1	297.1	294.2	349.8	345.1	297.2	294.6	350.1	345.5	296.6	294.4	350.4	346.8	297.7	295.3	351.7
(8) Spokane, Washington (SPOK)	333.3	296.3	289.3	337.4	338.6	301.1	292.4	343.0	334.7	296.5	289.6	339.1	337.1	295.3	290.7	340.7
(9) Tehran, Iran (TEHRAN)	364.4	302.5	305.0	367.2	365.6	303.2	305.6	368.4	366.3	302.6	305.8	368.5	365.7	303.5	306.0	368.7
(10) Xining, China (XINING)	348.3	300.3	298.5	351.3	339.4	288.8	291.8	343.3	339.9	289.6	292.2	344.0	348.7	297.0	297.6	352.5
	Elevation Angle = 1°															
	00 00				06 00				12 00				18 00			
	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	233.0	199.4	203.1	235.9	233.2	201.9	204.3	239.1	226.5	190.4	198.9	229.9	226.7	191.0	198.9	229.4
(2) Amazon Forest (AMFOR)	284.7	221.9	230.4	281.0	283.9	221.9	229.7	280.7	283.8	222.0	229.8	280.7	283.9	221.8	231.0	280.4
(3) Bangkok, Thailand (BANGK)	280.9	221.3	230.2	274.7	276.5	216.9	226.6	271.1	279.3	218.9	228.0	273.1	281.3	220.0	229.1	274.0
(4) Washington, D.C. (DC)	235.5	206.6	204.2	238.6	237.9	207.8	204.6	240.6	244.6	209.7	206.7	245.3	251.4	210.2	210.2	251.2
(5) Alaska (NAK)	235.8	207.1	204.1	241.7	236.0	207.3	204.3	242.0	235.0	206.9	204.1	241.6	235.2	207.3	204.3	242.1
(6) Northern Australia, Tanami Desert (NAUS)	268.2	212.3	222.7	266.9	255.1	201.4	214.3	253.1	261.4	206.2	218.0	259.6	268.0	211.0	220.7	266.3
(7) Pyrenee Mountains (PYRNES)	237.4	207.8	205.2	243.0	237.6	207.7	205.5	243.2	237.7	207.3	205.4	243.5	238.2	208.0	205.9	244.2
(8) Spokane, Washington (SPOK)	231.4	208.6	202.1	235.1	234.2	211.7	203.8	238.4	232.1	208.4	202.1	236.2	233.5	206.7	202.5	237.2
(9) Tehran, Iran (TEHRAN)	249.5	209.0	211.5	253.6	250.3	209.4	211.9	254.1	251.1	208.6	211.9	253.5	250.6	209.5	212.1	253.9
(10) Xining, China (XINING)	240.9	209.7	208.3	244.0	235.6	201.4	204.3	240.0	236.1	202.0	204.6	240.6	241.2	206.9	207.7	245.4
	Elevation Angle = 3°															
	00 00				06 00				12 00				18 00			
	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	132.7	116.7	119.6	135.0	132.1	118.1	120.0	136.5	130.0	111.6	118.0	132.8	130.2	112.0	117.9	132.5
(2) Amazon Forest (AMFOR)	153.6	126.1	132.8	150.2	153.3	126.3	132.4	150.3	153.1	126.3	132.5	150.2	153.1	126.0	133.1	149.8
(3) Bangkok, Thailand (BANGK)	150.9	125.8	132.7	145.5	150.1	123.6	131.1	145.4	150.9	124.6	131.7	145.4	151.9	125.2	132.2	145.7
(4) Washington, D.C. (DC)	133.5	121.3	119.6	136.2	135.0	122.0	119.7	137.3	138.4	122.8	120.7	139.2	141.4	122.4	122.6	141.4
(5) Alaska (NAK)	132.5	121.2	119.2	137.1	132.5	121.3	119.2	137.2	132.0	121.1	119.1	137.1	132.0	121.3	119.2	137.2
(6) Northern Australia, Tanami Desert (NAUS)	147.0	121.3	129.2	145.6	143.1	115.6	125.4	141.4	145.7	118.1	127.1	144.2	147.8	120.7	128.2	146.2
(7) Pyrenee Mountains (PYRNES)	133.2	121.6	119.8	137.5	133.3	121.5	120.0	137.7	133.3	121.3	120.0	137.8	133.5	121.6	120.2	138.1
(8) Spokane, Washington (SPOK)	130.5	122.6	118.0	133.5	131.5	124.4	118.7	135.0	130.6	122.4	117.8	134.1	131.1	121.0	118.1	134.2
(9) Tehran, Iran (TEHRAN)	139.3	121.2	123.3	142.4	139.6	121.4	123.5	142.5	139.9	120.8	123.5	141.7	139.6	121.5	123.6	142.1
(10) Xining, China (XINING)	135.5	122.6	121.7	137.9	133.2	117.6	119.9	136.7	133.6	118.0	120.1	137.2	135.8	120.7	121.5	139.1
	Elevation Angle = 5°															
	00 00				06 00				12 00				18 00			
	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	89.5	79.8	82.0	91.2	89.0	80.7	82.2	92.1	87.8	76.3	81.1	90.0	88.0	76.5	81.0	89.8
(2) Amazon Forest (AMFOR)	101.9	85.5	90.5	99.1	101.8	85.6	90.2	99.2	101.7	85.6	90.3	99.1	101.6	85.3	90.7	98.7
(3) Bangkok, Thailand (BANGK)	100.1	85.2	90.4	95.6	99.8	83.8	89.5	96.0	100.2	84.5	89.8	95.8	100.8	84.8	90.2	95.9
(4) Washington, D.C. (DC)	89.8	83.0	81.7	91.9	90.8	83.5	81.8	92.6	93.0	83.9	82.4	93.8	94.8	83.5	83.7	94.9
(5) Alaska (NAK)	88.9	82.8	81.4	92.3	88.9	82.9	81.4	92.3	88.6	82.8	81.3	92.3	88.5	82.9	81.4	92.4
(6) Northern Australia, Tanami Desert (NAUS)	98.0	82.3	88.3	96.6	95.9	78.5	85.9	94.6	97.6	80.2	87.0	96.3	98.7	81.9	87.6	97.2
(7) Pyrenee Mountains (PYRNES)	89.3	83.1	81.8	92.5	89.4	83.0	82.0	92.6	89.4	82.9	82.0	92.7	89.5	83.1	82.1	92.9
(8) Spokane, Washington (SPOK)	87.5	83.9	80.5	90.0	88.2	85.1	80.9	90.9	87.6	83.7	80.4	90.3	87.9	82.7	80.6	90.2
(9) Tehran, Iran (TEHRAN)	93.3	82.6	84.3	95.5	93.5	82.8	84.4	95.5	93.6	82.3	84.4	94.9	93.4	82.8	84.5	95.2
(10) Xining, China (XINING)	90.9	83.8	83.1	92.8	89.6	80.3	82.1	92.2	89.8	80.6	82.2	92.6	91.2	82.4	83.1	93.7
	Elevation Angle = 10°															
	00 00				06 00				12 00				18 00			
	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	48.0	43.3	44.6	49.0	47.7	43.8	44.7	49.5	47.2	41.4	44.2	48.5	47.3	41.5	44.2	48.4
(2) Amazon Forest (AMFOR)	54.2	46.0	49.1	52.4	54.1	46.1	48.9	52.4	54.0	46.1	49.0	52.4	54.0	46.0	49.2	52.2
(3) Bangkok, Thailand (BANGK)	53.2	45.9	49.0	50.5	53.1	45.2	48.6	50.8	53.3	45.5	48.7	50.6	53.6	45.7	48.9	50.6
(4) Washington, D.C. (DC)	48.1	45.1	44.4	49.3	48.7	45.3	44.4	49.7	49.8	45.5	44.7	50.3	50.7	45.2	45.4	50.8
(5) Alaska (NAK)	47.6	44.9	44.1	49.5	47.6	45.0	44.1	49.5	47.4	44.9	44.1	49.5	47.4	45.0	44.1	49.5
(6) Northern Australia, Tanami Desert (NAUS)	52.3	44.4	48.0	51.3	51.3	42.4	46.8	50.5	52.1	43.3	47.3	51.3	52.6	44.2	47.6	51.7
(7) Pyrenee Mountains (PYRNES)	47.8	45.1	44.4	49.6	47.8	45.0	44.5	49.6	47.8	45.0	44.5	49.7	47.9	45.1	44.5	49.8
(8) Spokane, Washington (SPOK)	46.8	45.6	43.6	48.3	47.1	46.2	43.8	48.7	46.8	45.5	43.5	48.4	47.0	44.9	43.7	48.4
(9) Tehran, Iran (TEHRAN)	49.9	44.7	45.7	51.1	49.9	44.8	45.8	51.1	50.0	44.6	45.8	50.7	49.9	44.8	45.8	50.9
(10) Xining, China (XINING)	48.7	45.4	45.1	49.7	48.0	43.5	44.6	49.5	48.1	43.7	44.7	49.7	48.8	44.7	45.1	50.2

Table 9 — Time Delay (ns) for Selected Areas of Interest
MRF, Goad, and Exponential Model for 15 August 1995
(0000, 0600, 1200, and 1800 h)

AOI	Elevation Angle = 0°															
	00 00				06 00				12 00				18 00			
	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	334.0	271.6	282.5	327.5	334.0	278.2	287.2	335.7	334.0	262.7	278.2	318.7	334.0	255.9	271.2	307.8
(2) Amazon Forest (AMFOR)	423.4	326.1	335.2	418.2	423.9	326.3	334.3	418.4	423.9	326.5	334.8	417.5	416.7	323.6	333.8	411.5
(3) Bangkok, Thailand (BANGK)	449.3	335.5	344.9	442.7	446.3	334.1	343.9	439.3	443.7	332.8	342.5	436.6	454.7	337.9	347.3	444.7
(4) Washington, D.C. (DC)	444.4	333.7	344.2	433.8	444.9	335.1	343.9	433.1	439.7	334.1	342.1	428.5	432.4	329.2	339.3	422.7
(5) Alaska (NAK)	364.7	302.8	303.7	366.6	366.3	303.6	304.6	368.0	364.7	303.1	304.1	366.5	365.7	304.1	305.0	367.8
(6) Northern Australia, Tanami Desert (NAUS)	336.7	287.8	291.7	340.6	322.7	272.4	281.6	325.7	332.2	283.2	288.4	335.7	338.3	289.2	292.4	341.5
(7) Pyrenee Mountains (PYRNES)	376.8	306.5	312.4	377.2	373.3	306.0	312.5	374.1	371.2	304.7	311.3	372.2	374.7	305.6	312.0	375.5
(8) Spokane, Washington (SPOK)	359.8	294.7	300.8	360.4	368.6	301.9	306.1	368.6	367.8	302.6	305.9	368.5	373.1	304.4	309.4	373.7
(9) Tehran, Iran (TEHRAN)	363.2	291.9	303.0	361.6	338.5	274.1	288.9	336.8	295.9	242.8	260.0	288.8	317.7	260.4	274.3	313.8
(10) Xining, China (XINING)	450.5	337.3	345.5	447.3	462.4	340.9	351.6	455.2	440.9	331.8	342.5	432.7	418.1	322.7	332.1	415.1
	Elevation Angle = 1°															
	00 00				06 00				12 00				18 00			
	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	229.8	189.3	199.6	231.2	233.3	193.5	202.1	235.8	226.0	183.0	197.6	226.5	220.8	179.3	193.6	219.9
(2) Amazon Forest (AMFOR)	278.7	219.6	228.6	279.0	278.6	220.0	227.9	279.0	278.3	220.1	228.3	278.0	276.0	217.9	227.9	275.0
(3) Bangkok, Thailand (BANGK)	296.4	224.6	233.9	294.3	294.4	223.8	233.4	291.9	293.1	223.0	232.6	290.9	297.2	226.0	235.2	293.6
(4) Washington, D.C. (DC)	287.9	223.4	233.8	284.0	288.2	224.7	233.5	282.8	286.1	224.4	232.4	280.1	282.1	221.1	231.1	277.3
(5) Alaska (NAK)	249.5	209.6	210.7	253.2	250.6	209.9	211.2	253.8	249.4	209.7	210.9	252.8	250.0	210.3	211.4	253.5
(6) Northern Australia, Tanami Desert (NAUS)	233.9	200.8	204.6	238.1	227.8	190.5	199.2	229.7	232.1	197.8	202.9	235.4	234.7	201.8	204.8	238.3
(7) Pyrenee Mountains (PYRNES)	256.0	210.0	215.9	258.5	254.5	209.6	215.9	256.8	253.6	208.8	215.3	255.9	254.9	209.3	215.7	257.6
(8) Spokane, Washington (SPOK)	248.5	203.1	209.1	249.5	252.4	207.5	211.8	253.0	251.7	208.2	211.6	253.1	254.4	208.6	213.6	255.6
(9) Tehran, Iran (TEHRAN)	250.9	200.2	210.8	249.1	237.7	189.2	203.2	235.8	215.6	171.0	187.1	208.1	227.4	181.9	195.0	223.1
(10) Xining, China (XINING)	297.7	226.0	234.1	297.6	304.2	227.2	237.8	299.2	292.6	222.2	232.8	285.2	279.1	217.8	227.0	277.6
	Elevation Angle = 3°															
	00 00				06 00				12 00				18 00			
	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	132.0	110.5	118.4	133.2	133.2	112.8	119.4	135.1	130.9	106.8	117.8	131.5	128.8	105.0	115.8	128.4
(2) Amazon Forest (AMFOR)	150.7	125.0	131.9	150.5	150.6	125.3	131.5	150.4	150.4	125.4	131.8	149.6	149.8	124.0	131.7	148.6
(3) Bangkok, Thailand (BANGK)	159.8	127.3	134.5	157.9	158.8	126.8	134.3	156.6	158.5	126.5	133.9	156.5	159.5	127.9	135.1	156.4
(4) Washington, D.C. (DC)	153.8	126.6	134.6	150.2	154.0	127.5	134.3	149.1	153.2	127.5	133.8	147.9	151.4	125.6	133.3	147.0
(5) Alaska (NAK)	139.5	121.7	122.8	142.2	140.0	121.9	123.0	142.3	139.3	121.8	122.9	141.9	139.6	122.1	123.2	142.1
(6) Northern Australia, Tanami Desert (NAUS)	132.6	117.4	120.3	135.6	130.7	111.5	118.1	132.3	132.2	115.7	119.6	134.6	133.0	117.9	120.3	135.4
(7) Pyrenee Mountains (PYRNES)	142.2	121.1	125.7	143.9	141.7	120.8	125.8	143.2	141.4	120.4	125.5	143.0	141.7	120.7	125.7	143.6
(8) Spokane, Washington (SPOK)	139.6	117.7	122.3	140.4	140.5	120.0	123.4	140.9	140.0	120.4	123.2	141.0	140.8	120.3	124.3	141.6
(9) Tehran, Iran (TEHRAN)	141.0	115.5	123.6	139.4	135.7	109.7	120.2	134.3	127.5	100.5	112.7	122.6	132.4	106.4	116.3	129.5
(10) Xining, China (XINING)	160.3	128.1	134.5	160.0	162.8	128.3	136.4	158.6	158.0	126.0	134.1	151.8	151.8	124.2	131.3	150.2
	Elevation Angle = 5°															
	00 00				06 00				12 00				18 00			
	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	89.3	75.5	81.4	90.2	89.9	77.0	82.0	91.2	88.7	73.0	81.2	89.3	87.4	71.8	79.9	87.4
(2) Amazon Forest (AMFOR)	100.2	84.7	90.0	99.5	100.0	85.0	89.7	99.4	99.9	85.0	89.9	98.9	99.7	84.1	89.9	98.3
(3) Bangkok, Thailand (BANGK)	106.0	86.1	91.6	104.2	105.3	85.8	91.5	103.3	105.1	85.6	91.2	103.4	105.7	86.6	92.0	103.0
(4) Washington, D.C. (DC)	101.9	85.7	91.7	98.7	102.0	86.3	91.5	97.9	101.5	86.3	91.1	97.1	100.4	85.1	90.9	96.6
(5) Alaska (NAK)	93.5	83.0	83.9	95.4	93.9	83.1	84.0	95.5	93.4	83.1	84.0	95.2	93.5	83.2	84.1	95.3
(6) Northern Australia, Tanami Desert (NAUS)	89.4	80.2	82.4	91.5	88.3	76.2	81.2	89.6	89.2	79.0	82.0	90.9	89.6	80.5	82.4	91.3
(7) Pyrenee Mountains (PYRNES)	95.2	82.4	85.9	96.2	94.9	82.2	86.0	95.9	94.8	81.9	85.8	95.7	94.9	82.1	85.9	96.1
(8) Spokane, Washington (SPOK)	93.6	80.2	83.7	94.2	94.0	81.7	84.3	94.2	93.7	82.0	84.1	94.3	94.1	81.8	84.9	94.5
(9) Tehran, Iran (TEHRAN)	94.6	78.6	84.7	93.4	91.6	74.8	82.7	90.6	86.9	68.8	78.0	83.7	89.8	72.7	80.2	88.0
(10) Xining, China (XINING)	106.3	86.7	91.6	105.7	107.7	86.7	92.9	104.3	104.8	85.3	91.4	99.9	101.0	84.2	89.6	99.5
	Elevation Angle = 10°															
	00 00				06 00				12 00				18 00			
	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	48.0	40.9	44.4	48.6	48.3	41.8	44.7	49.1	47.8	39.6	44.4	48.2	47.1	39.0	43.7	47.2
(2) Amazon Forest (AMFOR)	53.3	45.6	48.8	52.7	53.2	45.8	48.6	52.7	53.2	45.8	48.7	52.4	53.0	45.3	48.8	52.1
(3) Bangkok, Thailand (BANGK)	56.3	46.4	49.7	55.2	56.0	46.2	49.6	54.7	55.9	46.1	49.5	54.7	56.1	46.6	49.9	54.4
(4) Washington, D.C. (DC)	54.1	46.1	49.8	52.1	54.2	46.5	49.6	51.6	53.9	46.5	49.4	51.2	53.4	45.8	49.3	51.0
(5) Alaska (NAK)	50.0	44.9	45.5	51.1	50.2	45.0	45.6	51.1	50.0	45.0	45.6	50.9	50.0	45.1	45.6	51.0
(6) Northern Australia, Tanami Desert (NAUS)	48.0	43.5	44.8	49.1	47.5	41.4	44.3	48.2	47.9	42.9	44.6	48.9	48.1	43.7	44.8	49.0
(7) Pyrenee Mountains (PYRNES)	50.9	44.5	46.6	51.4	50.7	44.4	46.7	51.2	50.7	44.3	46.6	51.2	50.7	44.4	46.7	51.3
(8) Spokane, Washington (SPOK)	50.1	43.4	45.5	50.4	50.2	44.2	45.8	50.3	50.0	44.4	45.7	50.4	50.2	44.2	46.1	50.4
(9) Tehran, Iran (TEHRAN)	50.7	42.5	46.1	49.9	49.2	40.5	45.1	48.6	47.0	37.4	42.8	45.3	48.4	39.4	43.8	47.5
(10) Xining, China (XINING)	56.4	46.7	49.6	55.9	57.1	46.7	50.3	55.0	55.6	45.9	49.6	52.8	53.7	45.4	48.6	52.8

Table 10 — Angle Error (degrees) for Selected Areas of Interest
MRF, Goad, and Exponential Model for 15 February 1997
(0000, 0600, 1200, and 1800 h)

AOI	0000 MRF	0000 Goad	0000 Exp.	0600 MRF	0600 Goad	0600 Exp.	1200 MRF	1200 Goad	1200 Exp.	1800 MRF	1800 Goad	1800 Exp.
	Elevation Angle = 0°											
(1) Ahaggar, Algeria (AHAGR)	0.2701	0.5756	0.2635	0.2912	0.5906	0.2709	0.2346	0.5311	0.2397	0.2362	0.5330	0.2381
(2) Amazon Forest (AMFOR)	0.4807	0.9099	0.4489	0.4786	0.9040	0.4453	0.4852	0.9029	0.4473	0.4867	0.9144	0.4500
(3) Bangkok, Thailand (BANGK)	0.5054	0.9090	0.4623	0.4467	0.8637	0.4301	0.4617	0.8850	0.4458	0.4684	0.8946	0.4537
(4) Washington, D.C. (DC)	0.2672	0.5833	0.2724	0.2660	0.5886	0.2737	0.2734	0.6193	0.2876	0.2960	0.6689	0.3100
(5) Alaska (NAK)	0.3048	0.6169	0.2833	0.3061	0.6201	0.2847	0.3072	0.6160	0.2824	0.3113	0.6187	0.2843
(6) Northern Australia, Tanami Desert (NAUS)	0.4198	0.8229	0.3834	0.3078	0.7295	0.3106	0.3496	0.7693	0.3343	0.3978	0.8060	0.3655
(7) Pyrenee Mountains (PYRNES)	0.3096	0.6189	0.2914	0.3089	0.6214	0.2912	0.3107	0.6193	0.2912	0.3163	0.6260	0.2936
(8) Spokane, Washington (SPOK)	0.2731	0.5845	0.2762	0.2875	0.6030	0.2861	0.2768	0.5945	0.2755	0.2788	0.6130	0.2749
(9) Tehran, Iran (TEHRAN)	0.3372	0.6933	0.3157	0.3385	0.6969	0.3198	0.3309	0.7020	0.3239	0.3324	0.6989	0.3230
(10) Xining, China (XINING)	0.3003	0.6310	0.2956	0.2857	0.6065	0.2739	0.2842	0.6053	0.2734	0.3007	0.6339	0.2901
	Elevation Angle = 1°											
(1) Ahaggar, Algeria (AHAGR)	0.2376	0.4225	0.2326	0.2528	0.4319	0.2386	0.2141	0.3939	0.2128	0.2122	0.3952	0.2114
(2) Amazon Forest (AMFOR)	0.3939	0.6179	0.3813	0.3918	0.6144	0.3784	0.3944	0.6138	0.3795	0.3965	0.6205	0.3822
(3) Bangkok, Thailand (BANGK)	0.4055	0.6173	0.3914	0.3723	0.5904	0.3666	0.3853	0.6029	0.3795	0.3878	0.6087	0.3845
(4) Washington, D.C. (DC)	0.2402	0.4301	0.2396	0.2398	0.4336	0.2408	0.2464	0.4511	0.2522	0.2648	0.4783	0.2705
(5) Alaska (NAK)	0.2623	0.4483	0.2494	0.2638	0.4501	0.2506	0.2635	0.4478	0.2487	0.2662	0.4494	0.2502
(6) Northern Australia, Tanami Desert (NAUS)	0.3476	0.5658	0.3328	0.2773	0.5095	0.2791	0.2990	0.5336	0.2952	0.3312	0.5556	0.3206
(7) Pyrenee Mountains (PYRNES)	0.2665	0.4498	0.2549	0.2662	0.4511	0.2547	0.2670	0.4498	0.2547	0.2704	0.4537	0.2568
(8) Spokane, Washington (SPOK)	0.2430	0.4317	0.2423	0.2532	0.4432	0.2501	0.2460	0.4368	0.2432	0.2514	0.4458	0.2478
(9) Tehran, Iran (TEHRAN)	0.2875	0.4912	0.2754	0.2895	0.4934	0.2786	0.2875	0.4959	0.2823	0.2885	0.4946	0.2812
(10) Xining, China (XINING)	0.2631	0.4575	0.2589	0.2486	0.4402	0.2412	0.2476	0.4399	0.2406	0.2614	0.4578	0.2543
	Elevation Angle = 3°											
(1) Ahaggar, Algeria (AHAGR)	0.1506	0.2530	0.1481	0.1573	0.2577	0.1516	0.1393	0.2380	0.1368	0.1378	0.2387	0.1361
(2) Amazon Forest (AMFOR)	0.2322	0.3475	0.2327	0.2310	0.3458	0.2311	0.2316	0.3456	0.2315	0.2329	0.3488	0.2332
(3) Bangkok, Thailand (BANGK)	0.2355	0.3471	0.2376	0.2220	0.3339	0.2245	0.2286	0.3400	0.2316	0.2298	0.3429	0.2339
(4) Washington, D.C. (DC)	0.1537	0.2579	0.1516	0.1540	0.2597	0.1524	0.1588	0.2680	0.1592	0.1691	0.2805	0.1700
(5) Alaska (NAK)	0.1639	0.2659	0.1586	0.1648	0.2667	0.1593	0.1642	0.2656	0.1582	0.1653	0.2664	0.1590
(6) Northern Australia, Tanami Desert (NAUS)	0.2085	0.3217	0.2072	0.1766	0.2936	0.1781	0.1862	0.3057	0.1869	0.2013	0.3166	0.2011
(7) Pyrenee Mountains (PYRNES)	0.1660	0.2668	0.1610	0.1659	0.2674	0.1609	0.1661	0.2668	0.1609	0.1676	0.2687	0.1621
(8) Spokane, Washington (SPOK)	0.1558	0.2587	0.1535	0.1608	0.2645	0.1579	0.1575	0.2609	0.1546	0.1608	0.2645	0.1581
(9) Tehran, Iran (TEHRAN)	0.1775	0.2861	0.1734	0.1789	0.2872	0.1751	0.1797	0.2882	0.1775	0.1796	0.2878	0.1765
(10) Xining, China (XINING)	0.1649	0.2710	0.1624	0.1573	0.2613	0.1536	0.1567	0.2613	0.1530	0.1640	0.2705	0.1605
	Elevation Angle = 5°											
(1) Ahaggar, Algeria (AHAGR)	0.1042	0.1747	0.1026	0.1082	0.1778	0.1050	0.0969	0.1650	0.0951	0.0961	0.1655	0.0946
(2) Amazon Forest (AMFOR)	0.1566	0.2349	0.1584	0.1558	0.2338	0.1573	0.1561	0.2337	0.1576	0.1569	0.2358	0.1587
(3) Bangkok, Thailand (BANGK)	0.1582	0.2347	0.1613	0.1501	0.2262	0.1529	0.1542	0.2301	0.1575	0.1551	0.2320	0.1590
(4) Washington, D.C. (DC)	0.1065	0.1780	0.1048	0.1068	0.1792	0.1054	0.1103	0.1844	0.1099	0.1170	0.1923	0.1172
(5) Alaska (NAK)	0.1128	0.1828	0.1096	0.1134	0.1834	0.1100	0.1129	0.1827	0.1093	0.1136	0.1832	0.1098
(6) Northern Australia, Tanami Desert (NAUS)	0.1413	0.2184	0.1419	0.1217	0.2004	0.1228	0.1277	0.2081	0.1287	0.1371	0.2151	0.1379
(7) Pyrenee Mountains (PYRNES)	0.1142	0.1835	0.1111	0.1141	0.1839	0.1110	0.1142	0.1835	0.1110	0.1151	0.1847	0.1118
(8) Spokane, Washington (SPOK)	0.1079	0.1784	0.1060	0.1112	0.1821	0.1089	0.1090	0.1797	0.1067	0.1111	0.1819	0.1091
(9) Tehran, Iran (TEHRAN)	0.1217	0.1958	0.1195	0.1227	0.1965	0.1206	0.1235	0.1971	0.1221	0.1233	0.1969	0.1215
(10) Xining, China (XINING)	0.1136	0.1864	0.1120	0.1087	0.1799	0.1063	0.1083	0.1800	0.1058	0.1131	0.1859	0.1108
	Elevation Angle = 10°											
(1) Ahaggar, Algeria (AHAGR)	0.0564	0.0948	0.0555	0.0583	0.0964	0.0568	0.0527	0.0899	0.0516	0.0522	0.0901	0.0514
(2) Amazon Forest (AMFOR)	0.0832	0.1257	0.0846	0.0828	0.1251	0.0841	0.0830	0.1250	0.0842	0.0834	0.1261	0.0848
(3) Bangkok, Thailand (BANGK)	0.0839	0.1255	0.0861	0.0799	0.1212	0.0818	0.0820	0.1232	0.0842	0.0825	0.1242	0.0849
(4) Washington, D.C. (DC)	0.0577	0.0965	0.0567	0.0579	0.0971	0.0570	0.0598	0.0998	0.0594	0.0632	0.1038	0.0632
(5) Alaska (NAK)	0.0608	0.0989	0.0592	0.0611	0.0992	0.0594	0.0609	0.0988	0.0590	0.0612	0.0991	0.0593
(6) Northern Australia, Tanami Desert (NAUS)	0.0754	0.1172	0.0761	0.0656	0.1079	0.0662	0.0687	0.1119	0.0693	0.0734	0.1155	0.0741
(7) Pyrenee Mountains (PYRNES)	0.0615	0.0993	0.0600	0.0615	0.0995	0.0599	0.0616	0.0993	0.0599	0.0620	0.0999	0.0604
(8) Spokane, Washington (SPOK)	0.0584	0.0966	0.0572	0.0601	0.0985	0.0588	0.0590	0.0972	0.0576	0.0601	0.0983	0.0589
(9) Tehran, Iran (TEHRAN)	0.0655	0.1056	0.0644	0.0660	0.1059	0.0650	0.0664	0.1062	0.0658	0.0663	0.1061	0.0654
(10) Xining, China (XINING)	0.0613	0.1008	0.0604	0.0588	0.0974	0.0575	0.0586	0.0975	0.0572	0.0611	0.1005	0.0598

Table 11 — Angle Error (degrees) for Selected Areas of Interest
MRF, Goad, and Exponential Model for 15 August 1997
(0000, 0600, 1200, and 1800 h)

AOI	0000 MRF	0000 Goad	0000 Exp.	0600 MRF	0600 Goad	0600 Exp.	1200 MRF	1200 Goad	1200 Exp.	1800 MRF	1800 Goad	1800 Exp.
	Elevation Angle = 0°											
(1) Ahaggar, Algeria (AHAGR)	0.2542	0.5535	0.2437	0.2851	0.5818	0.2597	0.2288	0.5278	0.2259	0.1994	0.4878	0.2095
(2) Amazon Forest (AMFOR)	0.4824	0.8894	0.4265	0.4875	0.8853	0.4275	0.4904	0.8862	0.4313	0.5383	1.0088	0.5159
(3) Bangkok, Thailand (BANGK)	0.4914	0.9510	0.4533	0.4900	0.9438	0.4519	0.4840	0.9362	0.4431	0.5214	0.9648	0.4711
(4) Washington, D.C. (DC)	0.5401	0.9405	0.4825	0.5402	0.9411	0.4885	0.5255	0.9307	0.4829	0.5140	0.9090	0.4701
(5) Alaska (NAK)	0.3457	0.6860	0.3182	0.3450	0.6926	0.3217	0.3462	0.6876	0.3202	0.3468	0.6930	0.3235
(6) Northern Australia, Tanami Desert (NAUS)	0.2886	0.5957	0.2751	0.2340	0.5401	0.2459	0.2701	0.5779	0.2647	0.2930	0.6033	0.2790
(7) Pyrenee Mountains (PYRNES)	0.3706	0.7421	0.3414	0.4329	0.8780	0.4293	0.3518	0.7341	0.3308	0.3662	0.7391	0.3376
(8) Spokane, Washington (SPOK)	0.3093	0.6775	0.3047	0.3368	0.7154	0.3269	0.3385	0.7140	0.3259	0.3492	0.7386	0.3367
(9) Tehran, Iran (TEHRAN)	0.3134	0.6876	0.3146	0.2581	0.6018	0.2636	0.1440	0.4327	0.1782	0.1985	0.5122	0.2199
(10) Xining, China (XINING)	0.4893	0.9555	0.4580	0.5081	0.9913	0.4905	0.4699	0.9326	0.4664	0.4417	0.8648	0.4226
	Elevation Angle = 1°											
	MRF	Goad	Exp.	MRF	Goad	Exp.	MRF	Goad	Exp.	MRF	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	0.2203	0.4058	0.2168	0.2401	0.4233	0.2300	0.2005	0.3889	0.2019	0.1809	0.3647	0.1884
(2) Amazon Forest (AMFOR)	0.3895	0.6056	0.3651	0.3913	0.6032	0.3657	0.3923	0.6038	0.3678	0.4418	0.6770	0.4325
(3) Bangkok, Thailand (BANGK)	0.4009	0.6422	0.3874	0.3995	0.6379	0.3863	0.3937	0.6334	0.3800	0.4157	0.6505	0.4001
(4) Washington, D.C. (DC)	0.4284	0.6363	0.4065	0.4280	0.6366	0.4102	0.4202	0.6304	0.4056	0.4132	0.6176	0.3961
(5) Alaska (NAK)	0.2912	0.4874	0.2776	0.2921	0.4912	0.2804	0.2921	0.4883	0.2790	0.2942	0.4916	0.2816
(6) Northern Australia, Tanami Desert (NAUS)	0.2530	0.4342	0.2420	0.2163	0.3989	0.2178	0.2401	0.4231	0.2334	0.2558	0.4387	0.2450
(7) Pyrenee Mountains (PYRNES)	0.3109	0.5190	0.2964	0.3674	0.5991	0.3661	0.2993	0.5142	0.2880	0.3081	0.5172	0.2934
(8) Spokane, Washington (SPOK)	0.2716	0.4802	0.2696	0.2938	0.5028	0.2890	0.2949	0.5022	0.2880	0.3071	0.5162	0.2994
(9) Tehran, Iran (TEHRAN)	0.2773	0.4852	0.2770	0.2330	0.4329	0.2368	0.1428	0.3300	0.1673	0.1844	0.3795	0.1992
(10) Xining, China (XINING)	0.4051	0.6449	0.3901	0.4219	0.6663	0.4163	0.3936	0.6314	0.3958	0.3707	0.5913	0.3606
	Elevation Angle = 3°											
	MRF	Goad	Exp.	MRF	Goad	Exp.	MRF	Goad	Exp.	MRF	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	0.1414	0.2432	0.1403	0.1506	0.2521	0.1480	0.1313	0.2342	0.1316	0.1216	0.2222	0.1235
(2) Amazon Forest (AMFOR)	0.2281	0.3414	0.2246	0.2285	0.3402	0.2248	0.2286	0.3406	0.2256	0.2585	0.3766	0.2603
(3) Bangkok, Thailand (BANGK)	0.2381	0.3593	0.2376	0.2371	0.3572	0.2369	0.2341	0.3550	0.2337	0.2436	0.3635	0.2439
(4) Washington, D.C. (DC)	0.2466	0.3566	0.2461	0.2464	0.3568	0.2475	0.2430	0.3538	0.2448	0.2392	0.3474	0.2399
(5) Alaska (NAK)	0.1790	0.2844	0.1751	0.1801	0.2862	0.1767	0.1795	0.2849	0.1757	0.1809	0.2865	0.1771
(6) Northern Australia, Tanami Desert (NAUS)	0.1580	0.2586	0.1537	0.1414	0.2403	0.1401	0.1521	0.2529	0.1490	0.1594	0.2608	0.1556
(7) Pyrenee Mountains (PYRNES)	0.1894	0.2993	0.1860	0.2223	0.3383	0.2247	0.1842	0.2969	0.1812	0.1880	0.2984	0.1843
(8) Spokane, Washington (SPOK)	0.1724	0.2799	0.1716	0.1838	0.2911	0.1827	0.1839	0.2909	0.1822	0.1908	0.2974	0.1889
(9) Tehran, Iran (TEHRAN)	0.1750	0.2820	0.1759	0.1513	0.2558	0.1530	0.1030	0.2042	0.1115	0.1254	0.2295	0.1305
(10) Xining, China (XINING)	0.2411	0.3607	0.2389	0.2507	0.3712	0.2529	0.2361	0.3541	0.2410	0.2223	0.3345	0.2216
	Elevation Angle = 5°											
	MRF	Goad	Exp.	MRF	Goad	Exp.	MRF	Goad	Exp.	MRF	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	0.0983	0.1682	0.0976	0.1041	0.1739	0.1027	0.0920	0.1624	0.0917	0.0857	0.1547	0.0863
(2) Amazon Forest (AMFOR)	0.1537	0.2310	0.1533	0.1539	0.2303	0.1534	0.1539	0.2305	0.1538	0.1737	0.2536	0.1764
(3) Bangkok, Thailand (BANGK)	0.1610	0.2425	0.1619	0.1603	0.2411	0.1614	0.1584	0.2397	0.1593	0.1642	0.2451	0.1659
(4) Washington, D.C. (DC)	0.1653	0.2408	0.1671	0.1652	0.2409	0.1679	0.1631	0.2390	0.1661	0.1606	0.2349	0.1630
(5) Alaska (NAK)	0.1227	0.1947	0.1207	0.1235	0.1958	0.1218	0.1231	0.1950	0.1211	0.1240	0.1960	0.1220
(6) Northern Australia, Tanami Desert (NAUS)	0.1087	0.1783	0.1064	0.0984	0.1665	0.0973	0.1050	0.1746	0.1033	0.1096	0.1797	0.1077
(7) Pyrenee Mountains (PYRNES)	0.1294	0.2042	0.1280	0.1509	0.2290	0.1533	0.1261	0.2026	0.1248	0.1284	0.2036	0.1268
(8) Spokane, Washington (SPOK)	0.1190	0.1917	0.1185	0.1261	0.1988	0.1258	0.1262	0.1986	0.1254	0.1305	0.2028	0.1298
(9) Tehran, Iran (TEHRAN)	0.1204	0.1930	0.1213	0.1051	0.1761	0.1062	0.0741	0.1430	0.0782	0.0887	0.1593	0.0911
(10) Xining, China (XINING)	0.1631	0.2434	0.1629	0.1693	0.2501	0.1718	0.1599	0.2391	0.1639	0.1506	0.2267	0.1514
	Elevation Angle = 10°											
	MRF	Goad	Exp.	MRF	Goad	Exp.	MRF	Goad	Exp.	MRF	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	0.0534	0.0914	0.0530	0.0563	0.0944	0.0557	0.0502	0.0885	0.0499	0.0470	0.0845	0.0470
(2) Amazon Forest (AMFOR)	0.0817	0.1237	0.0821	0.0818	0.1233	0.0821	0.0818	0.1234	0.0823	0.0921	0.1353	0.0940
(3) Bangkok, Thailand (BANGK)	0.0858	0.1295	0.0866	0.0854	0.1289	0.0863	0.0844	0.1281	0.0853	0.0873	0.1309	0.0886
(4) Washington, D.C. (DC)	0.0876	0.1287	0.0891	0.0876	0.1287	0.0895	0.0865	0.1277	0.0886	0.0852	0.1257	0.0870
(5) Alaska (NAK)	0.0660	0.1050	0.0651	0.0665	0.1056	0.0657	0.0662	0.1052	0.0653	0.0667	0.1057	0.0658
(6) Northern Australia, Tanami Desert (NAUS)	0.0586	0.0966	0.0576	0.0534	0.0906	0.0528	0.0568	0.0947	0.0559	0.0591	0.0973	0.0583
(7) Pyrenee Mountains (PYRNES)	0.0694	0.1099	0.0689	0.0806	0.1227	0.0820	0.0678	0.1091	0.0673	0.0689	0.1096	0.0683
(8) Spokane, Washington (SPOK)	0.0643	0.1034	0.0640	0.0679	0.1070	0.0678	0.0679	0.1070	0.0676	0.0701	0.1091	0.0699
(9) Tehran, Iran (TEHRAN)	0.0649	0.1041	0.0655	0.0570	0.0955	0.0575	0.0412	0.0785	0.0427	0.0487	0.0868	0.0496
(10) Xining, China (XINING)	0.0869	0.1300	0.0871	0.0901	0.1334	0.0917	0.0852	0.1278	0.0875	0.0804	0.1214	0.0811

Table 12 — Parametric Requirements for Tropospheric Models

Model / Parameter	MILLMAN Stratified	HOPFIELD MODEL	GOAD MODEL	BLAKE MODEL	EXPONENTIAL MODEL	CASE I
Grid Number	X	X	X	X	X	
Latitude	X	X	X	X	X	
Longitude	X	X	X	X	X	
Altitude	X	X	X	X	X	
Elevation Angle	X	X	X	X	X	X
Pressure (mb)	X	X	X	X	X	
Temperature (K)	X	X	X	X	X	
Relative Humidity	X	X	X	X	X	
Wet Height of Tropospheric		X	Calc'd			
Dry Height of Tropospheric		X	Calc'd			
Heihgt of Layers (meter)	X			X	X	
Wet Refractivity	Calc'd	Calc'd	Calc'd	Calc'd		
Dry Refractivity	Calc'd	Calc'd	Calc'd	Calc'd		
Total Refractivity	Calc'd	Calc'd	Calc'd	Calc'd		
Max Height(meter)	X	X	X	X	X	
Coefficient for Exponential(Gradient)				X		
Coefficient for Surface Refractivity				X		
Reference Height (meter)					Calc'd	
Refractivity Index Gradient				X		
Coefficient						X
Surface Pressure	Calc'd	Calc'd	Calc'd	Calc'd	Calc'd	
Surface Temperature	Calc'd	Calc'd	Calc'd	Calc'd	Calc'd	
Surface Relative Humidity	Calc'd	Calc'd	Calc'd	Calc'd	Calc'd	
Surface Refractivity	Calc'd	Calc'd	Calc'd	Calc'd	Calc'd	
Angle of Layers	Calc'd					
Water Vapor Pressure	Calc'd	Calc'd	Calc'd			
OUTPUT Error	Range Angle Time Delay	Range Time Delay	Range Angle Time Delay	Range Angle Time Delay	Range Angle Time Delay	Range Time Delay

X : Given parameters
Calc'd : Calculated parameters

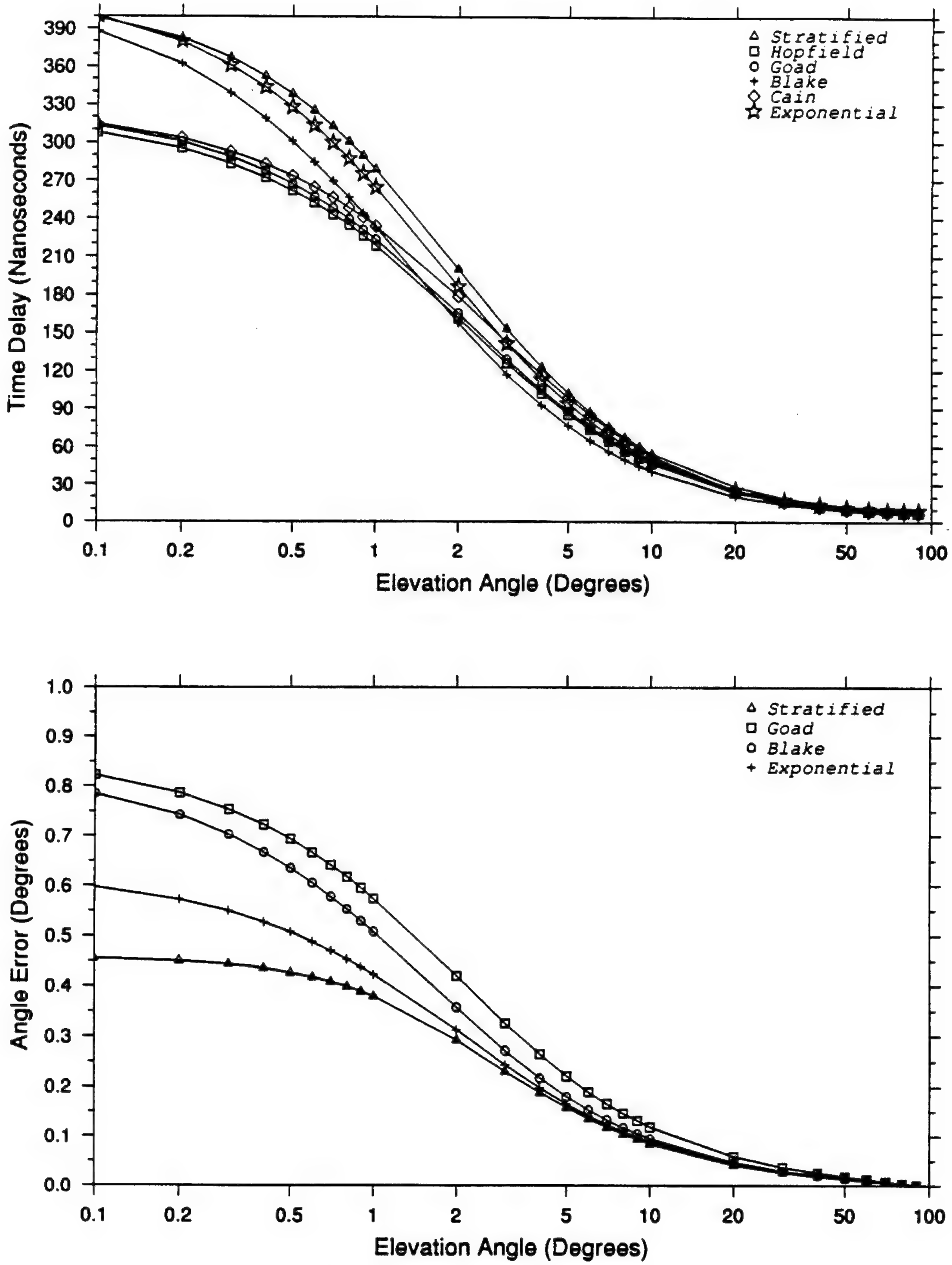
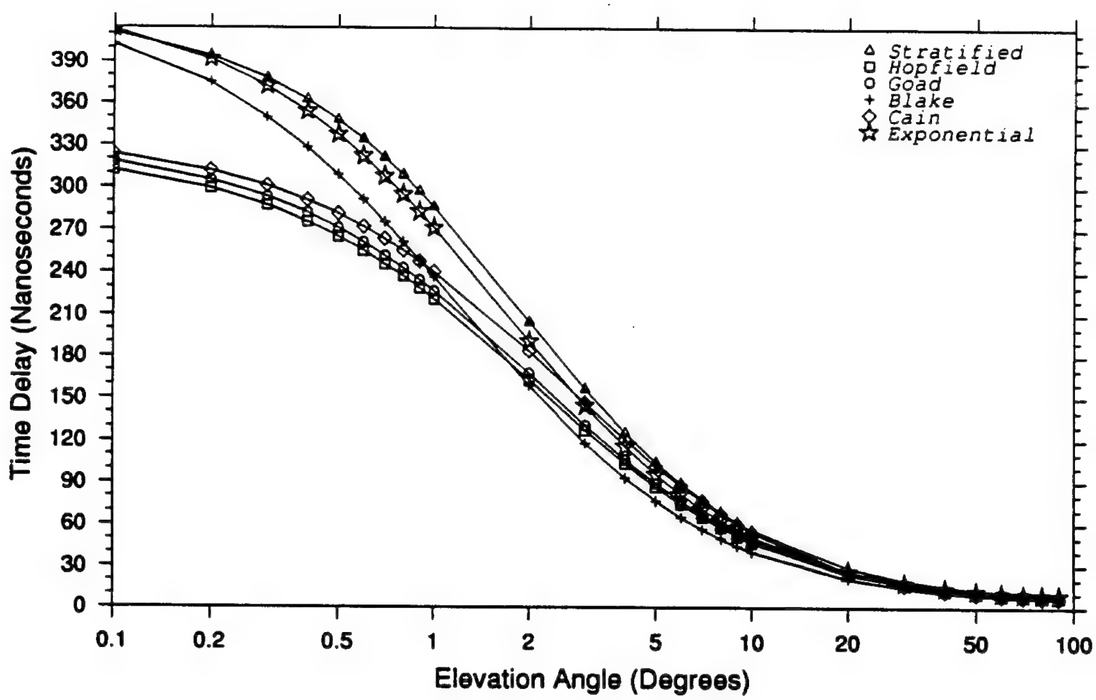


Fig. 19 — ECM database - AMFOR - February



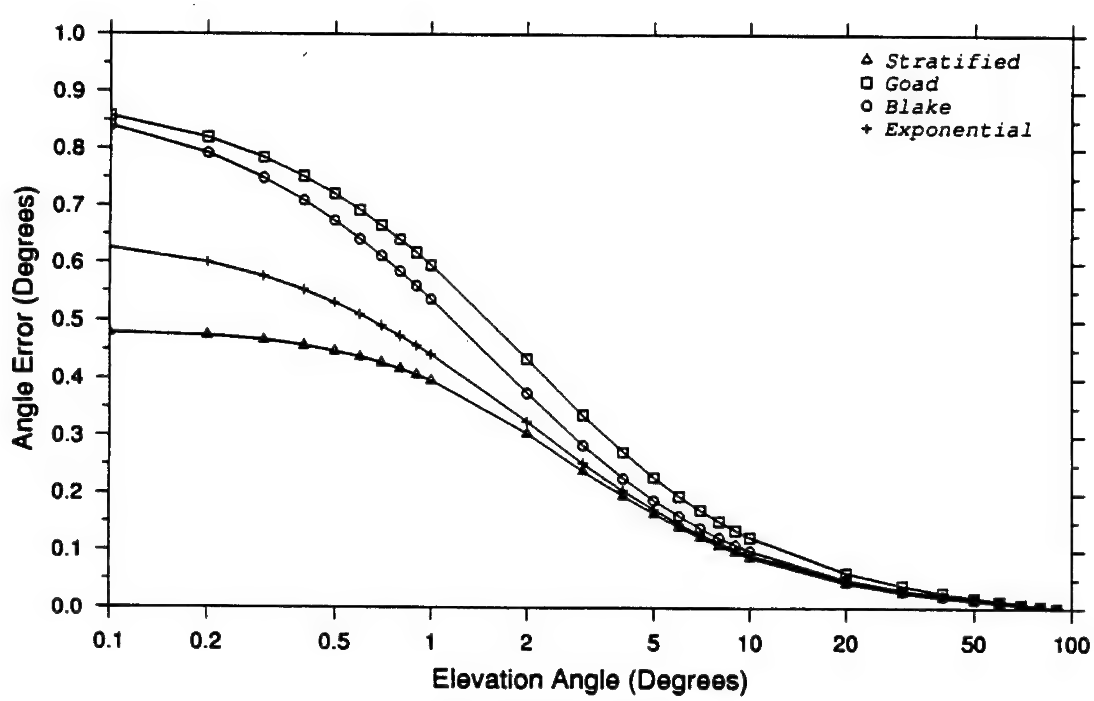


Fig. 20 — ECM database - AMFOR - May

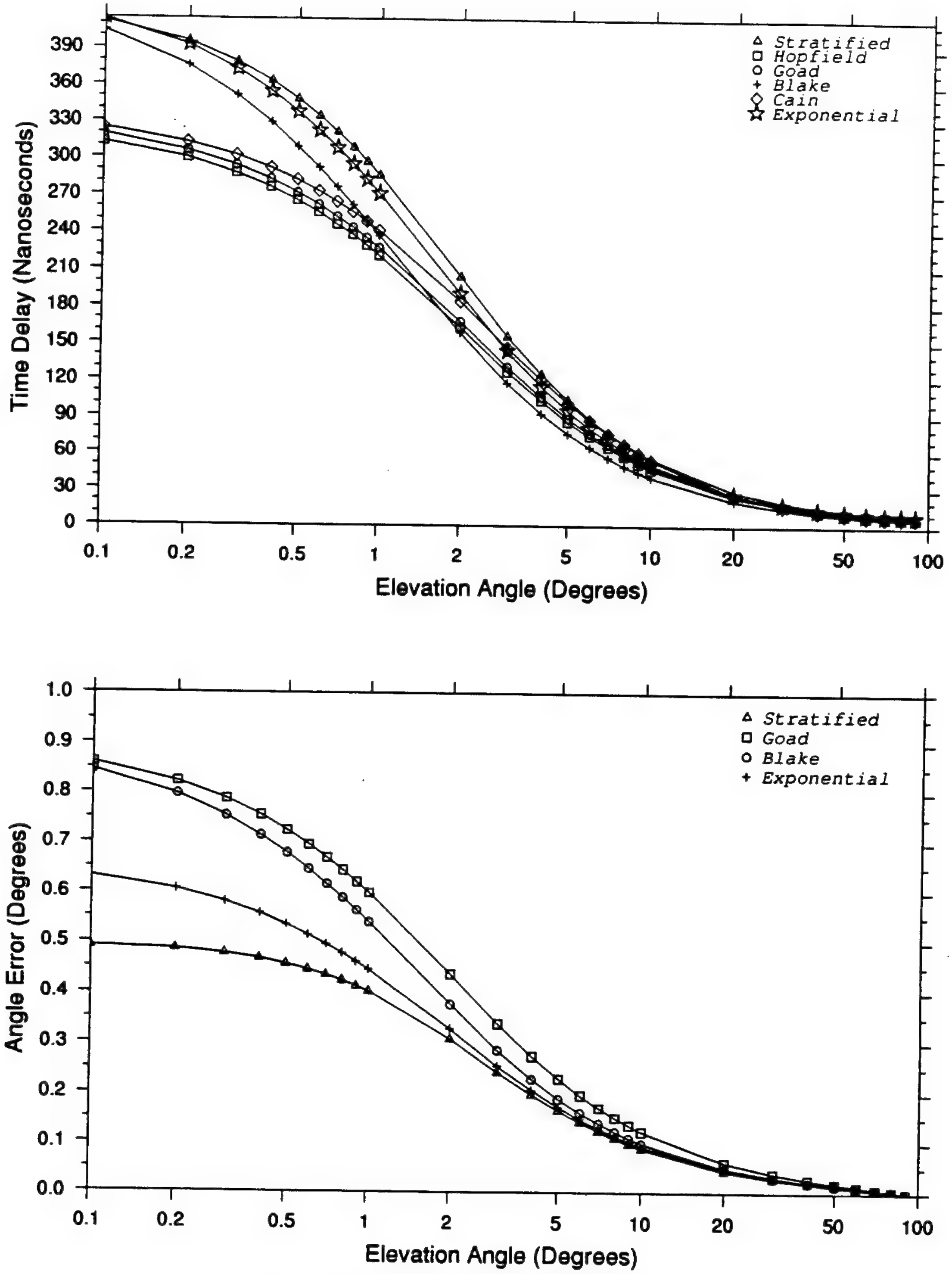
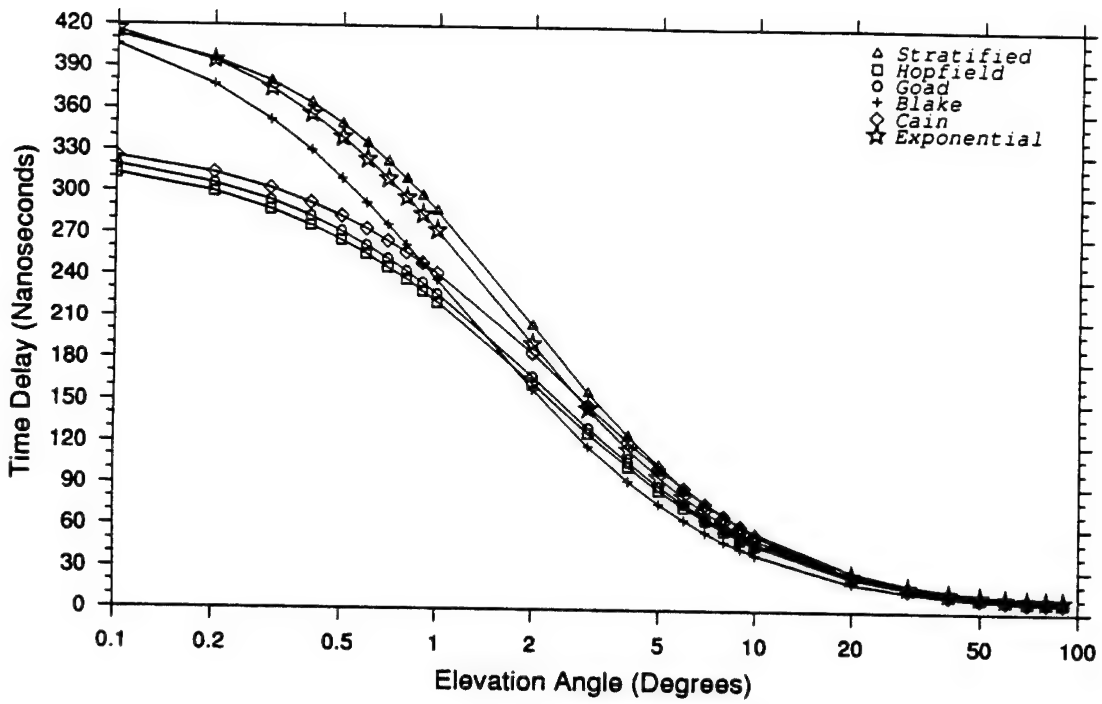


Fig. 21 — ECM database - AMFOR - August



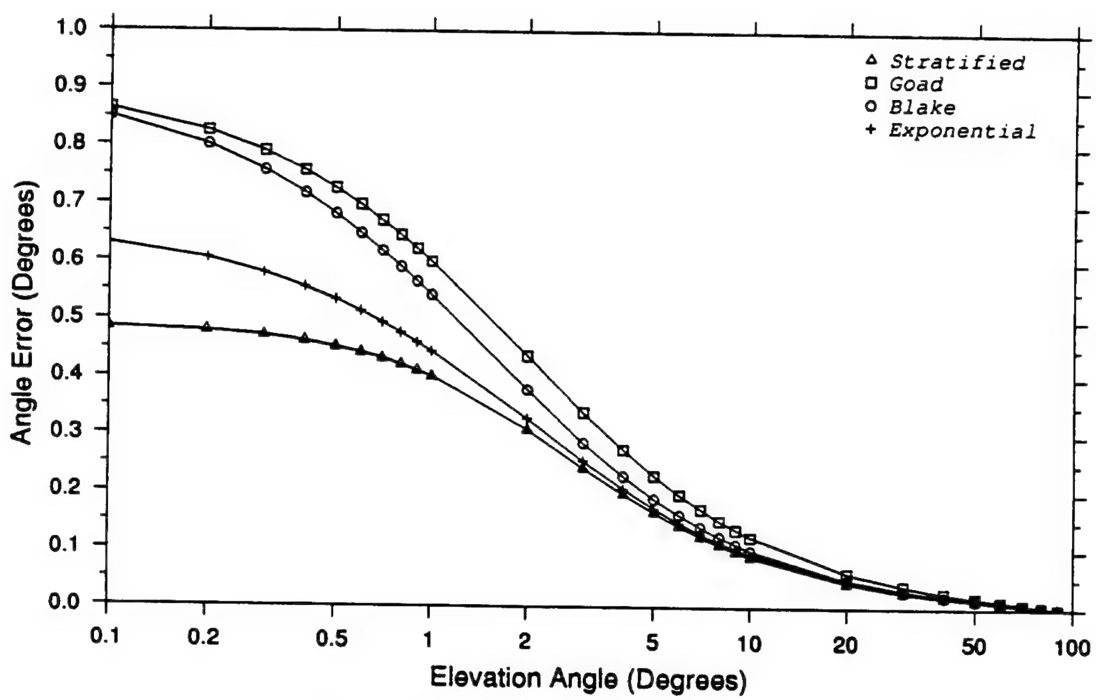


Fig. 22 — ECM database - AMFOR - November

4.3. Azimuth Angle Dependence of RF Ray Bending

It has been assumed that the refractive index of the atmosphere in ray-tracing studies is spherically stratified with respect to the surface of the Earth. Thus, the effect of refractive index changes in the horizontal direction is normally not considered. Equations (27) through (30) are subject to the following assumptions of ray tracing:

(1) The refractive index should not change appreciably in a wavelength.
(2) The fractional change in the spacing between neighboring rays (initially parallel) must be small in a wavelength.
(3) The refractive index structure is horizontally homogeneous.
(4) The refractive index is a function only of height above the surface of a smooth and spherical Earth.

Neglecting the effect of horizontal gradients seems reasonable in the tropospheric region because of the relatively slow horizontal change of refractive index in contrast to the rapid decrease with height. Bean and Dutton [1] performed two experiments (one over the Canterbury in New Zealand and the other at Cape Canaveral, Florida) to investigate assumption (3) (above) for horizontal changes of the refractive index. Their conclusion was not clear and mixed with the emphasis of ducting studies. Vogel [22] investigated monthly variations of refractivities and ducting for horizontal effects of radio wave propagation.

The importance here of this azimuth-angle dependence is to achieve a high accuracy in the low elevation angle (or horizon) for some over-the-horizon radio communication applications. For example, the search and surveillance mission over the horizon always encounters the atmospheric effect (tropospheric region) on RF propagation over an entire azimuth direction (over 360°). If one applies one uniform refractive index over entire azimuth direction, one can obtain erroneous results over each different azimuth-angle measurement. Figures 23 to 26 show time delay plots over each 90° azimuth direction over 360° from the months of February to November for six hourly averages between 1988 and 1994 in the Washington, D.C. area. The patterns of time delays over the entire azimuth direction vary hourly and seasonally. The variation of time delays for the months of May and August is sharply distinguishable from other monthly and hourly observations. The analysis is performed over several regions to find conclusive evidence. If the elevation angle is above 5°, the azimuth-angle dependence is almost negligible. If the elevation angle is between 0° and 3°, both time delay and range error should be carefully calibrated or calculated for correct tracking and navigation applications, including geolocation accuracy. Additional graphs are included in Appendix K for Teheran, Iran, and Ahaggar, Algeria.

5. CONCLUSIONS AND RECOMMENDATIONS

The major factors of model comparison criteria are based on the accuracy, minimum level of database or information requirement, and feasibility of real-time data application. Each model has advantages and disadvantages in each category. As we pointed out in Section 4, most of the comparisons are performed through time delay, range error, and angle-of-arrival error for different AOIs on different

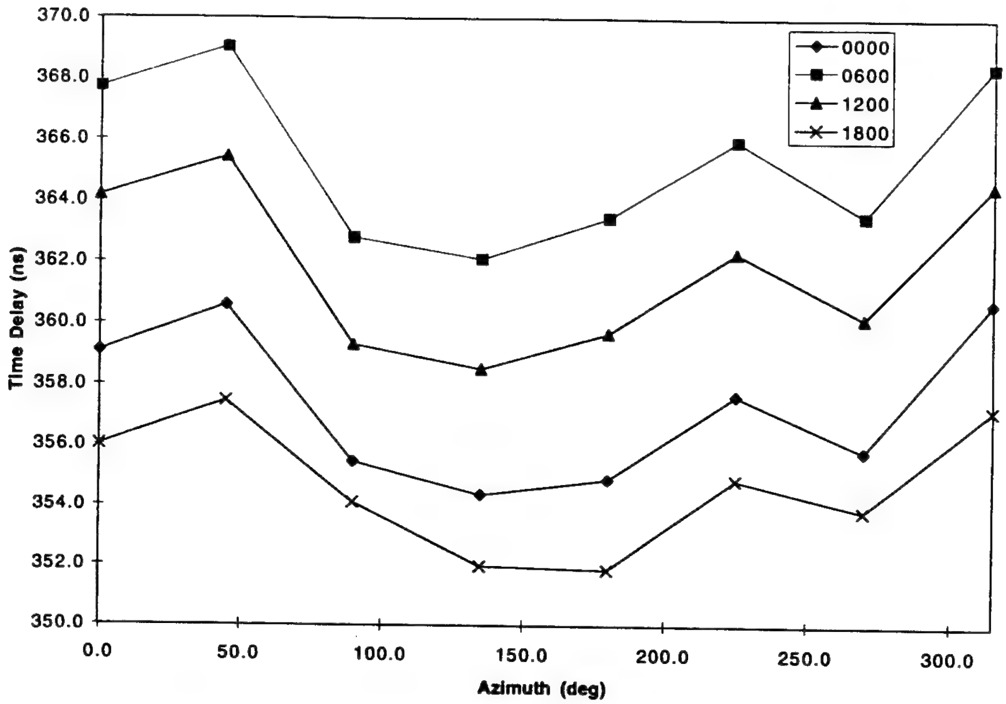


Fig. 23 — D.C., February (HIRAS surface data—0° elevation angle)

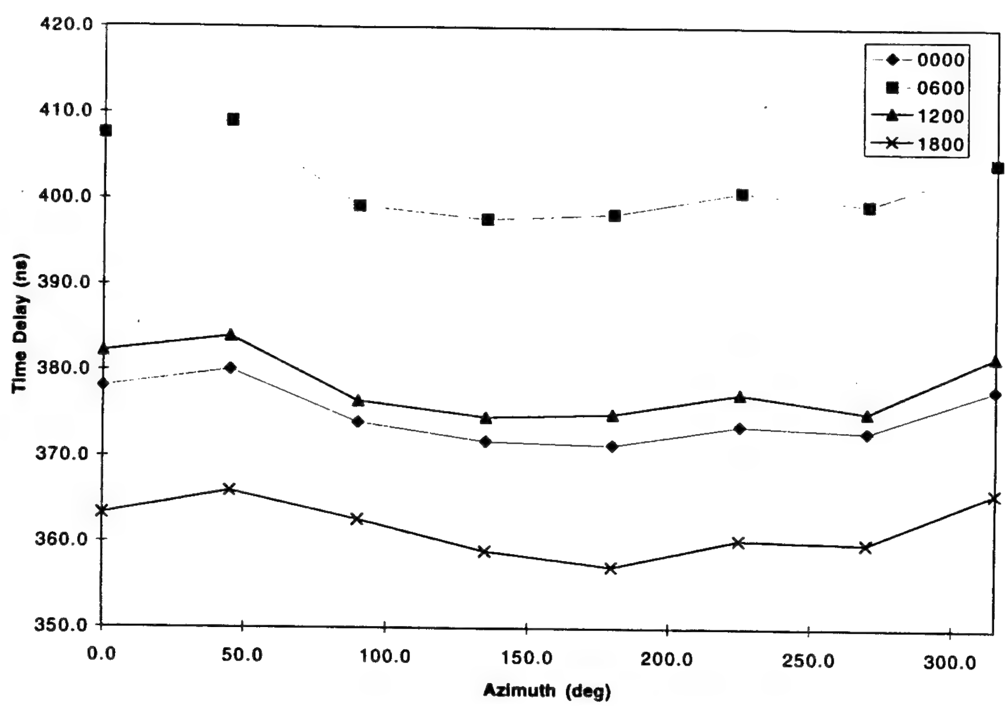


Fig. 24 — D.C., May (HIRAS surface data—0° elevation angle)

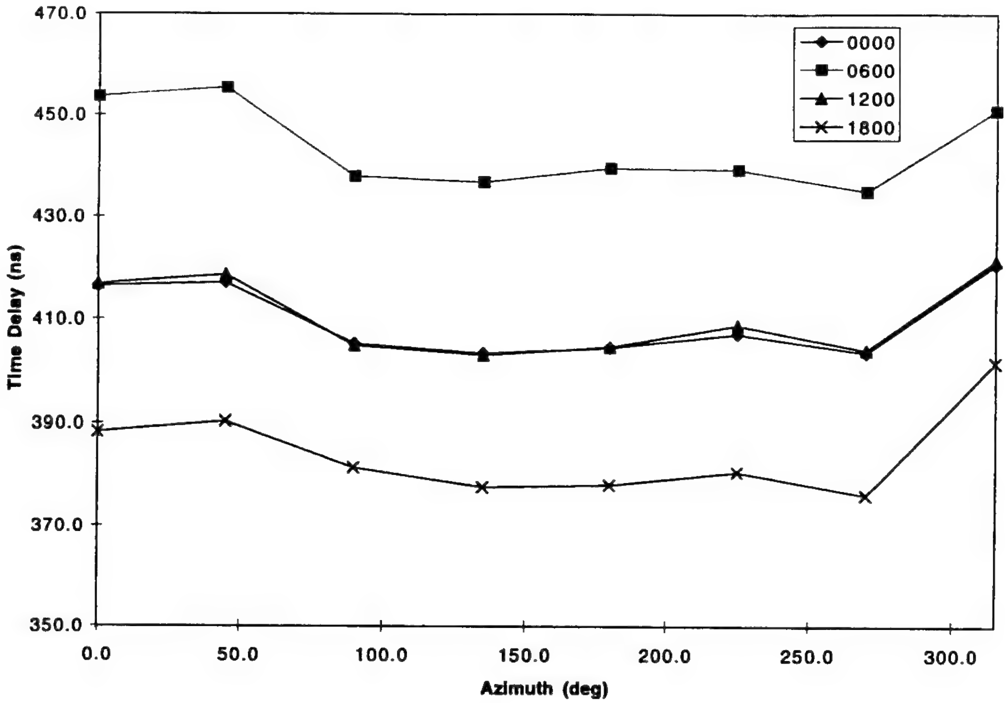


Fig. 25 — D.C., August (HIRAS surface data—0° elevation angle)

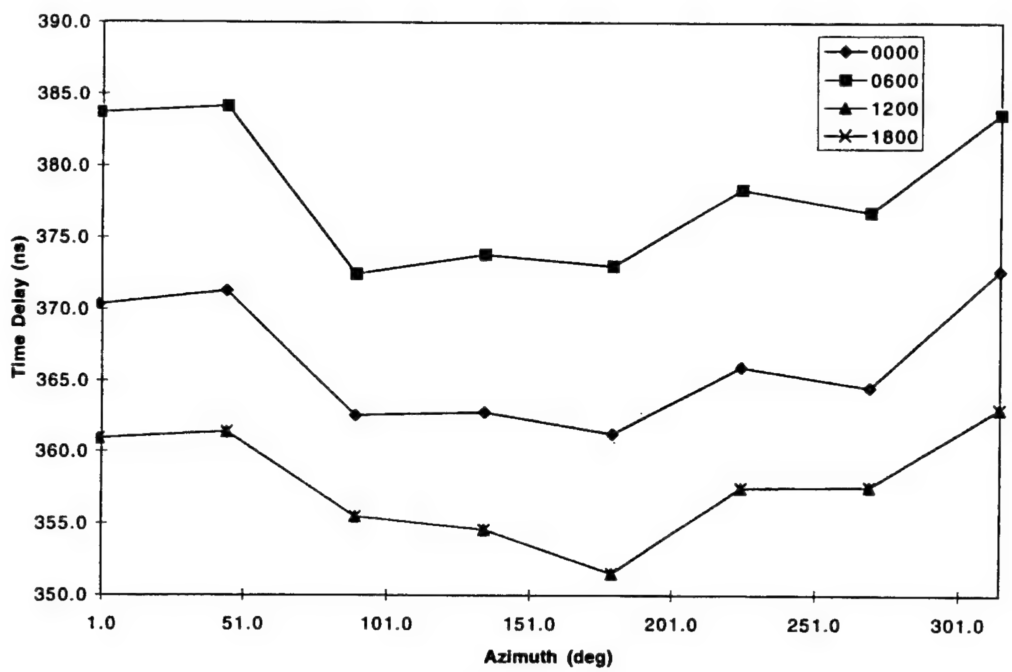


Fig. 26 — D.C., November (HIRAS surface data—0° elevation angle)

climatology to induce reasonable conclusions. A modified exponential model is proposed here as the best performer among many models evaluated based upon the three criteria level of accuracy, minimum level of database including surface weather data, and real-time data applicability. The modified exponential model outperforms in the accuracy improvement of range and time delay errors while surface weather data and reference height are required only to run ray-tracing algorithms for range, time delay, and angle-of-arrival error. This model also instantaneously accepts real-time weather data anytime and anywhere in the world. Several technical evaluation efforts are currently under way in programs and projects in many agencies and will be extended further. Preliminary results show promise for implementation to real operating systems in both tracking, surveillance, and navigation applications.

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Appendix A

REFERENCE (SCALE) HEIGHTS BY LATITUDE, LONGITUDE, AND MONTHS

Latitude is semented by 15° from –60° to +60°and by 30° from 60° to 90°. Longitude is divided by 90° from –180° to +180° for entire globe.

Reference Height (m)

NORTHERN HEMISPHERE

	Latitude	Longitude	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
High Latitudes:	60°N to 90°N	180°W to 90°W	7827.94	7810.24	7823.51	7893.80	8083.20	8096.40	8044.73	8036.33	8095.46	8059.39	7938.81	7883.13
		90°W to 0°W	7950.75	7923.00	7901.01	7928.70	8081.48	8073.09	8060.20	8055.47	8107.52	8069.14	8011.81	7971.38
		0° to 90°E	7999.65	8011.79	8014.17	7984.43	8085.39	8023.18	7951.59	7962.67	8042.63	8068.37	8053.33	8020.01
		90°E to 180°E	7782.71	7807.23	7834.65	7929.78	8099.31	8050.18	7958.33	7995.67	8101.56	8083.30	7938.70	7855.38
Upper Middle Latitudes:	45°N to 60°N	180°W to 90°W	8079.88	8088.09	8099.97	8041.94	7970.99	7833.98	7675.22	7646.19	7787.23	7951.61	8044.46	8051.50
		90°W to 0°W	8005.76	8035.75	8050.96	8016.57	7997.01	7834.96	7652.46	7614.25	7731.33	7903.39	7991.58	7999.00
		0° to 90°E	8173.59	8180.60	8205.63	8096.76	7966.38	7704.44	7566.71	7683.79	7871.94	8045.07	8146.55	8161.79
		90°E to 180°E	8029.34	8048.51	8134.59	8135.82	8099.17	7785.77	7511.85	7529.07	7878.95	8119.49	8121.03	8068.75
Mid Middle Latitudes:	30°N to 45°N	180°W to 90°W	7893.31	7902.78	7903.87	7753.52	7603.82	7406.94	7282.74	7201.88	7282.50	7495.52	7682.33	7817.68
		90°W to 0°W	7783.99	7806.69	7786.18	7644.68	7495.55	7242.14	7024.37	6979.11	7085.34	7321.46	7531.79	7679.08
		0° to 90°E	8127.42	8140.40	8064.72	7858.36	7765.66	7646.68	7496.45	7534.02	7701.73	7864.94	7996.23	8061.08
		90°E to 180°E	8033.00	8062.73	8050.95	7859.95	7652.36	7383.06	7102.89	6997.47	7258.95	7602.07	7868.15	7990.57
Lower Middle Latitudes:	15°N to 30°N	180°W to 90°W	7129.12	7165.02	7135.44	6990.37	6865.27	6760.37	6682.22	6619.37	6612.33	6701.70	6833.29	7008.88
		90°W to 0°W	7329.07	7340.73	7307.68	7200.01	7119.85	6928.21	6757.65	6733.25	6751.35	6901.03	7030.08	7185.22
		0° to 90°E	7978.36	8076.73	8011.69	7829.57	7678.93	7493.35	7327.86	7272.07	7393.50	7631.08	7791.31	7910.68
		90°E to 180°E	7132.71	7156.78	7024.86	6771.26	6636.13	6545.63	6463.50	6466.83	6466.72	6573.27	6761.27	6994.63

EQUATORIAL

	Latitude	Longitude	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Upper Low Latitudes:	0° to 15°N	180°W to 90°W	6555.13	6559.57	6539.75	6459.53	6470.32	6492.22	6516.84	6519.51	6504.94	6483.40	6511.51	6530.48
		90°W to 0°W	6811.91	6810.65	6766.86	6653.95	6624.19	6583.83	6564.11	6563.53	6555.40	6593.00	6642.99	6732.04
		0° to 90°E	7142.94	7187.20	7035.84	6757.63	6612.71	6621.06	6636.18	6611.31	6604.34	6706.66	6856.06	6987.21
		90°E to 180°E	6531.37	6559.33	6488.63	6388.11	6440.20	6468.16	6514.95	6520.89	6495.49	6493.95	6464.30	6506.86
Lower Low Latitudes:	15°S to 0°	180°W to 90°W	6567.08	6557.36	6520.80	6405.29	6420.62	6461.58	6530.22	6562.25	6545.69	6522.77	6542.88	6555.97
		90°W to 0°W	6672.69	6626.22	6604.47	6512.63	6579.50	6662.75	6753.67	6790.37	6786.17	6755.76	6725.07	6693.76
		0° to 90°E	6630.06	6607.08	6554.21	6450.89	6525.92	6663.52	6764.30	6829.56	6813.14	6726.61	6655.20	6621.02
		90°E to 180°E	6549.38	6561.81	6526.10	6436.34	6494.92	6590.54	6650.47	6637.07	6613.34	6587.10	6532.24	6516.99

SOUTHERN HEMISPHERE

	Latitude	Longitude	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lower Middle Latitudes:	30°S to 15°S	180°W to 90°W	6728.50	6661.87	6636.70	6650.92	6794.65	6918.90	6990.76	7025.91	7042.92	6974.72	6889.73	6796.87
		90°W to 0°W	6804.21	6731.81	6737.35	6768.41	6929.74	7082.77	7165.24	7192.53	7191.63	7111.65	6999.38	6886.31
		0° to 90°E	6753.70	6689.69	6692.70	6692.94	6904.62	7055.02	7160.99	7211.54	7216.58	7124.09	6977.59	6834.74
		90°E to 180°E	6982.96	6914.35	6971.76	7024.34	7184.07	7297.21	7379.62	7407.31	7423.93	7351.13	7210.23	7060.69
Mid Middle Latitudes:	45°S to 30°S	180°W to 90°W	7354.52	7308.81	7342.57	7376.19	7545.98	7631.40	7702.03	7724.27	7723.93	7661.96	7553.81	7449.28
		90°W to 0°W	7444.38	7375.99	7412.22	7459.45	7642.27	7732.01	7767.19	7783.37	7785.50	7728.23	7618.61	7517.27
		0° to 90°E	7410.58	7359.18	7389.17	7391.88	7565.82	7632.02	7688.41	7703.26	7694.89	7640.81	7574.12	7471.05
		90°E to 180°E	7518.02	7475.57	7514.86	7511.04	7645.64	7747.19	7803.99	7811.06	7785.88	7767.94	7690.08	7598.23
Upper Middle Latitudes:	60°S to 45°S	180°W to 90°W	7882.75	7879.66	7914.41	7909.97	8007.44	8057.19	8095.15	8088.41	8089.48	8025.34	7952.38	7922.03
		90°W to 0°W	7981.30	7971.98	7994.94	7981.98	8076.52	8117.94	8134.33	8135.36	8138.98	8112.00	8047.17	8012.29
		0° to 90°E	8017.91	8018.63	8021.33	7998.66	8082.15	8108.55	8125.17	8128.42	8128.13	8096.73	8071.26	8030.85
		90°E to 180°E	7926.38	7914.15	7952.13	7941.41	8036.11	8080.53	8114.46	8106.90	8081.12	8032.66	7992.61	7963.68
High Latitudes:	90°S to 60°S	180°W to 90°W	8073.89	8045.47	7997.12	7943.03	7987.80	7984.78	7992.33	7984.54	7988.27	8057.51	8092.66	8084.06
		90°W to 0°W	8090.99	8051.44	7988.78	7908.06	7952.35	7955.11	7951.66	7954.32	7967.97	8052.27	8116.59	8102.09
		0° to 90°E	8119.42	8045.35	7939.81	7850.10	7897.52	7895.62	7884.26	7875.30	7883.98	7959.76	8100.07	8115.23
		90°E to 180°E	8094.39	8019.00	7908.99	7822.44	7863.67	7863.62	7862.82	7870.69	7876.04	7956.12	8068.99	8104.12

Coefficients of Height & Associated Refractivites (Means) (Meters/N Units)

NORTHERN HEMISPHERE

	Latitudes	Longitudes	Element	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
High Latitudes:	60°N to 90°N	0°W to 90°W	hce(m)	8145.1100	8117.1369	8082.3852	8056.3767	8127.8629	8057.8550	8019.3303	8047.5644	8169.9256	8180.9404	8151.8760	8131.3152
			N(m)	309.41	310.10	310.33	311.15	314.40	318.50	320.61	319.29	312.69	309.51	310.00	309.43
Upper Middle Latitudes:	45°N to 60°N	0°E to 90°E	hce(m)	8097.4000	8088.7833	8037.2167	7845.5500	7607.5667	7365.8667	7157.5500	7211.2333	7297.0500	7585.5833	7911.9667	8032.9000
			N(m)	321.05	321.43	323.26	329.49	340.60	349.73	360.04	357.37	352.81	341.28	328.55	323.83
	45°N to 60°N	90°E to 180°E	hce(m)	8188.3111	8175.3556	8257.1111	8043.0778	7990.2333	7548.2111	7215.9556	7325.5222	7837.5000	8162.6222	8231.9556	8210.2000
			N(m)	317.23	316.56	313.86	320.80	325.45	341.43	354.70	350.66	333.05	319.81	316.10	316.54
	45°N to 60°N	90°W to 180°W	hce(m)	8140.2917	8126.6500	8130.7867	7999.9200	7791.4350	7555.2550	7439.6567	7521.1317	7752.5400	7947.4567	8062.8300	8063.6550
			N(m)	317.64	318.54	318.79	322.84	332.51	341.42	346.35	343.47	333.52	326.19	320.45	320.09
	45°N to 60°N	0°W to 90°W	hce(m)	8039.4733	8060.2067	8045.6022	7960.3533	7950.3067	7832.7289	7721.1133	7684.8156	7776.0022	7895.4000	7957.7067	8017.6822
			N(m)	316.77	316.48	316.57	321.70	324.25	329.53	333.91	334.51	329.24	322.70	320.53	316.77
Mid Middle Latitudes:	30°N to 45°N	0°E to 90°E	hce(m)	8036.7250	8014.9750	7827.4167	7583.2417	7617.7833	7808.2583	7688.0833	7721.7917	7956.6667	8038.5667	7990.3333	7966.2417
			N(m)	324.08	324.54	332.02	339.67	341.12	330.79	336.04	335.29	325.57	324.71	326.81	327.34
	30°N to 45°N	90°E to 180°E	hce(m)	8275.5323	8254.2091	8163.2881	7882.5625	7545.4260	7327.7805	7143.5024	7103.1199	7218.6566	7592.7227	8054.5703	8214.5765
			N(m)	313.94	314.53	318.54	328.24	342.95	354.57	366.27	367.29	360.49	341.11	324.08	317.14
	30°N to 45°N	90°W to 180°W	hce(m)	8147.4690	8143.7857	8134.4170	7970.5648	7724.3961	7489.7901	7436.8773	7403.6449	7632.9354	7876.2995	8048.2900	8102.5825
			N(m)	319.56	319.93	319.96	324.70	335.37	344.96	348.64	350.26	338.91	329.30	322.71	320.89
	30°N to 45°N	0°W to 90°W	hce(m)	8068.8339	8055.2785	8003.8375	7790.8807	7482.5953	7148.6855	6876.2139	6898.3982	7121.3428	7544.9401	7772.6938	7991.5911
			N(m)	319.52	320.68	323.01	330.00	344.08	358.86	372.49	371.31	359.68	341.53	332.20	322.90
Lower Middle Latitudes:	15°N to 30°N	0°E to 90°E	hce(m)	8180.5037	8323.5675	8253.2331	8087.7925	7937.2638	7701.3598	7553.0315	7523.8162	7589.5169	7790.0919	8028.0221	8191.0321
			N(m)	316.96	311.92	315.34	321.08	329.16	340.90	349.27	349.51	344.02	333.18	323.41	317.20
	15°N to 30°N	90°E to 180°E	hce(m)	7805.6500	7701.8250	7458.9375	7132.9250	6955.5500	7017.2375	7068.9875	7036.6375	6937.4750	6953.5000	7386.6125	7649.2875
			N(m)	329.63	333.48	343.48	359.09	371.64	377.36	381.08	381.03	382.79	370.02	347.37	336.55
	15°N to 30°N	90°W to 180°W	hce(m)	7711.2375	7750.3875	7792.7000	7481.0500	6998.4250	6694.5375	6723.1250	6718.6000	6642.2000	7038.0500	7360.4125	7632.3125
			N(m)	335.47	333.78	332.09	343.67	366.14	380.63	382.72	383.01	382.75	363.78	348.74	338.70
	15°N to 30°N	0°W to 90°W	hce(m)	7253.9815	7241.0205	7171.0260	7062.6590	6938.1935	6668.2915	6555.7315	6520.8325	6544.5360	6723.8500	6848.7370	7081.8255
			N(m)	352.92	353.19	356.44	359.57	367.26	382.39	388.04	389.94	387.26	377.03	370.03	360.58

EQUATORIAL

	Latitudes	Longitudes	Element	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Low Latitudes:	15°S to 15°N	0°E to 90°E	hce(m)	6862.5225	6868.9694	6741.6787	6493.4528	6535.1005	6667.1088	6750.3043	6791.2212	6755.4446	6671.1225	6643.6230	6730.2865
			N(m)	373.94	373.30	381.16	392.84	391.36	382.30	378.50	377.03	378.93	384.27	385.10	379.84
	15°S to 15°N	90°E to 180°E	hce(m)	6668.8000	6615.7875	6534.5250	6360.3000	6464.3750	6497.1125	6575.4000	6587.1750	6516.7250	6555.3625	6582.4375	6658.2250
			N(m)	387.04	389.11	394.35	401.28	401.56	401.03	396.30	395.58	399.18	398.51	394.97	387.90
	15°S to 15°N	0°W to 90°W	hce(m)	6711.4220	6700.5260	6675.1222	6576.1113	6608.2637	6666.1554	6737.6848	6746.9614	6718.1986	6693.1793	6668.5858	6683.3522
			N(m)	384.48	385.05	387.41	390.77	389.10	384.76	379.52	379.30	382.27	386.14	386.91	386.24

SOUTHERN HEMISPHERE

	Latitudes	Longitudes	Element	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
High Latitudes:	60°S to 15°S	90°E to 180°E	hce(m)	7408.1900	7270.7150	7400.5250	7677.2800	7895.5600	8015.1300	8146.1750	8150.6850	8257.0800	8043.9600	7681.9100	7461.4750
			N(m)	349.84	354.92	349.79	334.81	327.55	322.32	316.57	315.82	312.78	322.05	337.31	346.24
	60°S to 15°S	0°W to 90°W	hce(m)	7320.1861	7273.7979	7246.6835	7298.2402	7394.5492	7480.7170	7530.7602	7561.9142	7554.8518	7529.5981	7447.5711	7391.8797
			N(m)	352.38	354.24	355.79	351.80	348.80	345.40	342.95	342.08	342.64	344.68	347.28	349.73

Appendix B

AVERAGE ANNUAL SURFACE REFRACTIVITIES AND MONTHLY DEVIATIONS FOR 10 AREAS OF INTEREST

Three databases—European Center for Medium-Range Weather Forcast (ECM), High-Resolution Analysis System (HIRAS), and Medium-Range Frequency (MRF)—have been compared hourly with mean and standard deviation for monthly deviations from average annual refractivity for 10 areas of interest.

Average Annual Surface Refractivities with Monthly Deviations for 10 Areas-of-Interest (Sources: ECM, HIRAS, and MRF Data)

Ahaggar, Algeria (AHAGR)

				Refractivity (N)		Deviations from Average Refractivity (N)											
Source	Day	Year	Hour	Mean	StDev	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
ECM	NA	NA	NA	302.2	7.7	0.6	-12.8	-8.5	-6.1	-4.0	2.9	8.8	13.7	7.9	2.2	-0.1	-4.5
HIRAS	NA	NA	0000	302.7	5.1	2.2	-0.8	-1.9	-1.4	0.7	-10.8	-0.6	1.0	-3.5	-1.3	10.2	6.3
			0600	309.3	5.3	-0.6	-2.5	-0.9	1.9	-3.1	-9.7	-3.7	3.7	-1.6	-0.9	11.8	5.6
			1200	297.8	7.7	6.6	5.0	-1.1	5.9	-3.2	-13.0	-0.9	-0.7	-11.5	-6.3	9.2	10.1
			1800	289.7	10.6	8.6	5.4	2.3	5.2	-1.3	-15.2	-9.0	-10.9	-12.6	-3.6	17.3	13.6
MRF	1st	1995	0000	290.5	13.6	1.8	15.8	-3.9	9.3	16.6	-19.3	-25.8	-13.1	-2.0	1.8	10.9	7.8
			0600	297.1	14.4	0.6	15.8	-11.2	13.1	19.1	-18.8	-23.8	-14.8	1.7	0.6	14.5	3.2
			1200	281.5	15.1	4.2	22.2	-1.8	22.0	-0.9	-18.7	-25.5	-18.7	-2.0	4.2	4.4	10.4
			1800	278.0	17.1	0.8	26.3	2.7	25.4	-4.8	-20.6	-27.4	-19.0	-3.4	0.8	1.9	17.5
MRF	15th	1995	0000	293.3	14.3	10.3	10.9	-1.9	-1.9	-14.5	-19.2	-7.9	0.2	-6.1	-13.4	11.1	32.4
			0600	300.9	16.2	9.3	8.4	17.8	-5.1	-16.2	-26.9	-3.1	2.2	-5.3	-18.6	6.1	31.3
			1200	281.9	15.4	3.0	8.7	30.5	-5.5	-13.8	-25.4	-4.9	0.7	-8.3	-11.7	5.0	21.6
			1800	279.5	16.1	4.7	10.1	31.7	-2.2	-14.5	-26.3	-9.2	-8.3	-12.2	-2.9	8.8	20.3
MRF	28th	1995	0000	289.8	11.9	5.5	-5.0	-6.9	-9.8	-17.5	-4.3	1.1	8.8	15.6	23.7	1.0	-12.2
			0600	295.2	14.4	9.1	-6.6	-7.3	-9.4	-19.4	-6.9	8.3	13.2	16.0	27.7	-11.4	-13.4
			1200	275.9	7.3	5.5	-2.8	0.2	-1.2	-11.3	-3.8	0.7	3.0	3.5	17.9	-5.4	-6.1
			1800	273.4	8.6	7.0	5.9	1.2	-0.7	-12.1	-18.0	-3.4	5.5	3.5	13.1	-4.4	2.5

Amazon Forest (AMFOR)

				Refractivity (N)		Deviations from Average Refractivity (N)											
Source	Day	Year	Hour	Mean	StDev	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
ECM	NA	NA	NA	389.5	4.8	-5.6	-8.8	-7.2	-1.6	2.2	4.7	2.4	3.2	3.3	4.5	4.3	-1.4
HIRAS	NA	NA	0000	385.6	6.5	-8.1	-11.8	-8.5	-4.2	3.9	5.3	4.1	6.0	5.7	4.1	4.7	-1.3
			0600	396.1	7.2	-9.9	-12.5	-9.5	-3.8	2.8	4.6	2.7	5.7	7.3	7.4	6.3	-1.2
			1200	384.6	4.6	-4.7	-4.0	-1.9	1.3	4.0	5.2	2.5	3.7	2.9	2.1	-10.5	-0.6
			1800	371.0	5.2	-6.7	-8.5	-6.8	-1.8	6.4	6.8	3.8	3.4	1.6	1.6	3.1	-2.8
MRF	1st	1995	0000	399.6	8.4	-10.1	-12.4	-6.3	-3.8	8.8	11.8	6.4	8.9	2.4	-10.1	4.2	0.1
			0600	398.5	6.4	-6.6	-8.2	-4.1	-0.7	9.2	10.6	4.7	6.3	1.6	-6.6	-2.1	-3.9
			1200	398.2	5.8	-6.4	-7.3	-3.3	0.8	9.0	8.5	4.8	4.4	0.6	-6.4	0.0	-4.5
			1800	392.9	10.8	-14.2	-11.3	-7.0	-3.9	11.9	14.7	13.0	11.7	1.2	-14.2	1.9	-3.8
MRF	15th	1995	0000	403.2	8.4	-8.0	-20.9	-2.5	3.9	4.9	11.2	6.2	6.5	2.3	0.4	0.7	-4.7
			0600	401.2	6.5	-6.6	-13.5	-2.9	2.8	5.7	6.7	6.1	5.9	3.2	1.8	-1.9	-7.0
			1200	400.6	5.6	-4.0	-12.7	0.9	4.5	2.7	7.0	1.7	5.7	2.1	0.0	-1.0	-6.9
			1800	397.7	9.9	-6.6	-19.7	-6.0	8.8	3.8	15.1	8.4	9.5	0.3	-0.9	-1.2	-11.6
MRF	28th	1995	0000	401.6	7.2	-11.3	-11.8	-4.0	5.7	6.9	8.6	7.2	1.6	4.5	0.6	-0.6	-7.4
			0600	400.2	5.9	-9.4	-8.6	0.1	6.0	6.8	6.1	4.8	0.5	4.4	-2.8	-1.2	-6.7
			1200	399.9	5.2	-8.9	-5.5	1.1	4.9	7.6	5.9	3.9	-1.6	2.9	-3.1	-1.9	-5.3
			1800	396.0	9.9	-14.4	-8.4	-1.8	6.8	15.5	13.7	10.8	-1.7	3.4	-6.7	-9.1	-8.1

Average Annual Surface Refractivities with Monthly Deviations for 10 Areas-of-Interest
(Sources: ECM, HIRAS, and MRF Data)

Bangkok, Thailand (BANGK)

				Refractivity (N)		Deviations from Average Refractivity (N)											
Source	Day	Year	Hour	Mean	StDev	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
ECM	NA	NA	NA	390.2	6.0	-10.5	-3.7	2.3	7.8	6.5	6.3	-1.0	0.4	0.9	0.8	1.2	-10.9
HIRAS	NA	NA	0000	391.8	5.0	-1.8	1.0	2.9	6.0	7.1	2.8	1.1	-1.7	-0.7	0.5	-6.1	-11.1
			0600	370.2	9.6	-9.9	-9.7	-4.9	0.6	7.7	10.7	7.6	8.2	8.8	5.7	-6.3	-18.6
			1200	389.8	6.7	-9.1	-7.8	-1.2	5.0	6.0	4.8	3.5	1.0	2.3	5.0	4.6	-14.0
			1800	407.3	10.6	-9.4	-5.3	0.8	9.6	12.3	10.1	6.6	3.8	4.6	2.7	-12.8	-23.1
MRF	1st	1995	0000	403.2	15.4	-9.2	-33.3	0.9	20.4	8.8	14.1	16.8	7.2	6.2	-9.2	-12.3	-10.4
			0600	400.1	19.2	-21.4	-32.4	-5.7	20.6	15.0	20.1	15.3	14.4	14.2	-21.4	-18.9	0.2
			1200	397.9	19.2	-24.0	-38.2	2.9	17.0	13.5	15.2	14.6	17.5	12.1	-24.0	-8.2	1.8
			1800	400.6	19.2	-21.1	-41.2	10.7	17.1	10.7	16.1	16.5	12.3	12.6	-21.1	-10.0	-2.6
MRF	15th	1995	0000	405.8	14.2	-28.4	-3.7	-13.4	14.8	6.8	15.2	4.0	9.6	14.4	5.4	-6.0	-18.6
			0600	402.4	17.2	-36.7	-12.8	-17.3	11.6	15.1	11.4	10.5	10.6	17.6	10.6	-3.7	-16.9
			1200	401.8	14.7	-36.9	-5.5	-11.5	9.9	6.9	11.4	11.6	8.2	12.5	8.8	-3.9	-11.5
			1800	406.8	16.3	-40.4	-8.1	-5.5	5.1	17.7	17.4	8.5	12.5	8.3	5.1	-10.9	-9.7
MRF	28th	1995	0000	404.0	16.5	-4.2	1.2	9.8	8.5	11.3	7.0	4.7	9.9	13.0	3.7	-21.7	-43.1
			0600	402.6	17.4	-8.9	-14.4	11.7	11.8	12.3	3.7	12.9	7.4	12.4	8.9	-13.8	-44.2
			1200	402.5	15.7	-10.3	-7.6	7.0	3.0	7.6	8.7	9.6	10.1	18.1	5.0	-10.2	-41.1
			1800	406.5	16.8	-13.0	-4.3	10.0	1.7	6.4	12.0	10.6	9.7	19.1	3.2	-11.2	-44.0

Washington, D.C. (DC)

				Refractivity (N)		Deviations from Average Refractivity (N)											
Source	Day	Year	Hour	Mean	StDev	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
ECM	NA	NA	NA	342.9	24.9	-28.2	-25.6	-21.4	-13.0	3.7	23.7	38.1	37.9	22.5	-1.2	-11.1	-25.6
HIRAS	NA	NA	0000	337.0	22.5	-21.5	-23.6	-20.8	-16.5	0.9	19.8	33.8	34.4	23.5	2.1	-11.2	-20.8
			0600	355.9	32.5	-33.7	-34.5	-28.6	-16.2	5.5	33.6	52.2	47.7	26.1	-2.1	-18.5	-31.7
			1200	339.7	22.4	-21.1	-21.5	-17.3	-11.2	2.5	21.3	34.8	33.4	20.9	1.7	-23.5	-20.0
			1800	325.2	16.1	-12.8	-14.9	-13.7	-14.2	-0.2	13.6	27.2	26.4	13.9	-4.0	-8.9	-12.5
MRF	1st	1995	0000	350.7	31.1	-12.0	-38.1	0.2	-36.2	5.0	-3.2	50.1	46.8	39.1	-12.0	-3.5	-36.3
			0600	352.4	30.3	-10.4	-35.0	-10.6	-32.2	-5.0	4.7	42.4	48.1	44.6	-10.4	0.3	-36.5
			1200	349.7	32.1	-15.0	-38.8	-16.5	-32.9	-9.7	12.7	45.8	50.6	44.7	-15.0	6.6	-32.5
			1800	350.6	32.1	-17.4	-31.3	-17.7	-39.6	-7.7	14.9	53.9	45.9	34.8	-17.4	15.5	-33.9
MRF	15th	1995	0000	358.7	36.7	2.5	-49.3	-24.5	-44.3	26.9	-5.1	59.1	54.7	9.2	26.7	-38.4	-17.5
			0600	357.5	34.8	5.0	-46.1	-19.5	-36.3	19.3	-0.4	61.2	56.1	14.8	1.1	-42.7	-12.6
			1200	351.6	33.2	6.7	-31.3	-22.9	-32.2	17.3	3.3	60.8	58.1	10.4	-19.4	-38.9	-11.9
			1800	349.3	31.1	16.3	-16.0	-11.7	-37.1	10.7	-1.7	58.4	54.7	-5.6	-22.2	-38.8	-7.0
MRF	28th	1995	0000	356.5	36.8	-41.6	-5.1	-23.2	-15.3	9.7	45.5	64.3	44.9	-11.3	16.7	-36.5	-48.1
			0600	357.3	30.9	-38.5	-5.6	-22.1	-7.9	0.7	33.5	56.5	38.2	-11.4	16.2	-14.6	-45.1
			1200	351.5	30.1	-35.7	-2.8	-26.1	-10.9	6.1	36.9	54.3	40.2	-12.7	2.8	-11.3	-40.7
			1800	351.4	33.9	-27.0	4.1	-20.7	-23.8	19.9	44.3	62.9	41.1	-20.0	-25.0	-15.5	-40.3

Average Annual Surface Refractivities with Monthly Deviations for 10 Areas-of-Interest (Sources: ECM, HIRAS, and MRF Data)

Alaska (NAK)

Source	Day	Year	Hour	Refractivity (N)		Deviations from Average Refractivity (N)											
				Mean	StDev	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
ECM	NA	NA	NA	319.2	7.6	-9.8	-8.3	-6.4	-2.2	-0.4	2.7	8.0	13.2	10.1	3.6	-2.9	-7.6
HIRAS	NA	NA	0000	317.3	9.6	-9.4	-8.9	-8.3	-4.8	-0.6	5.3	15.4	17.7	7.9	0.2	-6.3	-8.2
			0600	317.9	11.3	-10.7	-10.3	-9.4	-5.7	-0.7	7.1	19.4	20.5	8.0	-1.2	-7.8	-9.4
			1200	317.5	10.0	-9.8	-9.6	-8.6	-4.8	-0.1	6.0	15.8	18.3	8.5	0.2	-7.4	-8.7
			1800	317.9	11.1	-10.7	-10.5	-9.5	-5.2	-0.4	7.2	18.8	20.2	7.8	-0.8	-7.8	-9.2
MRF	1st	1995	0000	319.0	8.5	-9.0	-6.9	-2.5	-2.9	-1.5	1.3	8.1	13.8	15.1	-9.0	-8.4	2.0
			0600	319.1	9.1	-9.8	-7.7	-1.6	-3.6	-2.5	0.7	8.8	13.9	17.5	-9.8	-8.0	2.0
			1200	319.1	9.1	-10.4	-7.7	-1.0	-3.9	-1.6	1.2	8.6	13.9	17.1	-10.4	-7.5	1.6
			1800	319.8	8.6	-8.9	-8.5	-2.6	-3.6	-0.8	0.7	8.4	13.6	16.1	-8.9	-6.5	0.9
MRF	15th	1995	0000	320.8	7.9	-4.8	-2.9	-7.3	-5.7	1.5	0.2	10.2	14.8	11.4	-2.4	-8.1	-7.0
			0600	321.4	8.1	-5.2	-2.8	-7.2	-5.4	1.2	1.3	11.5	15.5	10.0	-3.7	-8.4	-6.8
			1200	320.8	8.5	-6.0	-3.6	-7.3	-7.2	1.3	1.4	12.3	15.0	11.9	-4.0	-7.4	-6.4
			1800	321.2	8.3	-6.3	-2.9	-7.5	-6.8	1.1	1.8	11.7	15.9	10.6	-3.6	-7.8	-6.2
MRF	28th	1995	0000	321.8	8.1	-9.4	-6.7	-6.3	0.5	-1.7	3.4	9.8	19.1	1.8	-1.0	-1.5	-8.2
			0600	322.0	7.9	-9.6	-6.6	-5.9	-0.1	-1.1	4.4	10.1	18.0	1.7	-1.3	-2.4	-7.3
			1200	321.2	8.1	-10.4	-6.0	-6.0	-1.2	-0.9	4.7	8.6	19.2	3.9	-1.7	-2.8	-7.2
			1800	321.5	8.0	-10.6	-4.6	-4.9	-2.1	-2.2	6.6	9.3	18.1	2.6	-3.2	-1.3	-7.8

Northern Australia, Tanami Desert (NAUS)

Source	Day	Year	Hour	Refractivity (N)		Deviations from Average Refractivity (N)											
				Mean	StDev	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
ECM	NA	NA	NA	324.8	13.1	15.6	19.6	14.5	0.8	-3.9	-6.7	-11.4	-14.6	-18.7	-10.8	2.7	12.8
HIRAS	NA	NA	0000	326.3	7.6	8.0	12.5	-2.7	-3.2	-0.4	1.6	-4.7	-8.0	-9.4	-9.1	4.8	10.5
			0600	331.2	5.1	4.2	8.6	-2.6	-4.0	1.6	3.8	-2.3	-5.2	-6.4	-6.4	3.4	5.5
			1200	332.4	6.1	5.9	10.8	0.5	-3.8	-0.1	0.9	-5.6	-5.9	-8.3	-6.1	7.0	4.6
			1800	335.8	5.4	7.0	9.6	0.1	-2.4	-0.2	0.7	-5.5	-5.4	-6.9	-5.5	3.5	4.8
MRF	1st	1995	0000	328.8	22.9	-4.1	16.6	45.1	-22.5	34.7	-16.5	-13.6	-28.7	6.0	-4.1	-19.6	6.6
			0600	310.3	22.6	-8.5	13.5	36.9	-19.5	48.5	-7.4	-8.4	-24.3	2.7	-8.5	-21.7	-3.2
			1200	319.1	25.0	-10.8	5.6	41.3	-19.5	58.0	-3.7	-10.6	-24.1	2.2	-10.8	-20.9	-6.9
			1800	328.3	23.8	-4.0	-0.7	45.9	-21.0	48.1	-5.3	-14.8	-27.8	2.2	-4.0	-17.4	-1.1
MRF	15th	1995	0000	334.0	26.4	55.7	36.6	-6.9	-13.1	0.9	5.1	-19.1	-24.6	-16.4	-37.3	18.6	0.4
			0600	318.4	26.6	61.3	19.5	6.8	-19.3	10.3	1.0	-11.6	-26.6	-20.2	-34.6	23.9	-10.7
			1200	328.3	25.9	57.7	20.8	3.2	-20.0	11.7	-3.8	-13.2	-25.1	-15.0	-34.0	28.0	-10.1
			1800	340.9	28.6	51.1	24.7	32.9	-21.3	8.9	-13.6	-17.5	-29.3	-13.5	-44.4	25.8	-3.8
MRF	28th	1995	0000	324.1	28.7	57.8	33.3	-17.8	-8.5	-9.4	-9.4	-12.6	-9.6	-30.2	-41.4	21.6	26.2
			0600	307.3	27.1	63.5	25.2	-16.4	0.9	-12.2	-11.5	-12.5	-4.4	-28.4	-35.9	22.4	9.3
			1200	318.7	28.3	66.1	28.0	-16.7	1.4	-14.7	-12.7	-12.6	-7.0	-26.5	-38.2	23.8	9.3
			1800	329.2	29.6	65.6	31.9	-23.0	5.6	-16.7	-17.1	-14.8	-10.6	-23.7	-37.1	27.0	12.9

Average Annual Surface Refractivities with Monthly Deviations for 10 Areas-of-Interest
(Sources: ECM, HIRAS, and MRF Data)

Pyrenee Mountains (PYRNES)

Source	Day	Year	Hour	Refractivity (N) Mean	Refractivity (N) StDev	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
ECM	NA	NA	NA	342.5	14.0	-13.5	-15.4	-12.1	-8.9	-2.9	12.6	23.1	20.1	14.0	2.3	-6.5	-12.7
HIRAS	NA	NA	0000	340.9	14.2	-13.0	-15.2	-12.3	-12.0	-0.9	9.8	20.8	24.6	14.5	1.7	-6.4	-11.8
			0600	344.9	16.2	-15.9	-17.7	-13.0	-14.0	0.2	9.3	22.5	27.8	19.3	1.8	-7.3	-13.0
			1200	328.6	9.0	-6.8	-11.0	-10.8	-10.4	-3.4	6.3	10.3	14.1	8.9	1.3	6.5	-5.1
			1800	331.1	9.6	-5.7	-12.0	-12.3	-12.9	-4.7	3.0	7.0	14.0	12.7	8.5	4.0	-1.6
MRF	1st	1995	0000	340.2	17.7	-12.6	-8.0	-19.1	-16.1	3.1	-0.6	40.8	26.8	-0.1	-12.6	4.2	-5.8
			0600	339.5	17.5	-17.1	-6.4	-20.9	-9.0	1.8	1.0	33.9	31.7	3.8	-17.1	5.2	-6.9
			1200	334.0	16.7	-16.7	-5.6	-15.1	-2.2	-2.9	-2.9	40.2	22.8	-7.4	-16.7	6.6	-0.1
			1800	338.0	15.8	-18.3	-4.3	-8.0	6.9	-2.0	-1.4	36.6	20.3	-13.4	-18.3	3.2	-1.5
MRF	15th	1995	0000	337.4	15.3	-16.6	4.9	-9.4	-12.4	-8.4	-2.1	23.6	15.2	10.8	22.3	-5.2	-22.7
			0600	337.9	14.7	-16.6	4.8	-10.5	-10.1	-4.6	0.2	24.1	16.4	6.3	17.8	-2.8	-24.9
			1200	332.2	14.4	-7.8	10.4	-4.3	-19.3	4.6	-13.5	23.4	-3.9	6.6	22.7	1.4	-20.3
			1800	336.8	14.1	-12.6	8.8	-7.8	-11.0	11.5	-13.7	26.2	-12.9	6.9	15.9	5.0	-16.3
MRF	28th	1995	0000	340.7	18.2	-13.9	-19.1	-21.3	0.2	11.0	22.9	20.1	19.4	13.9	9.7	-21.2	-21.8
			0600	341.7	17.3	-6.3	-18.6	-20.9	-3.6	15.7	23.6	23.7	11.4	7.6	8.1	-20.4	-20.5
			1200	332.6	12.1	-4.0	-15.6	-16.2	9.5	8.6	22.9	7.3	-4.1	7.0	6.0	-12.9	-8.5
			1800	336.4	11.9	-2.4	-12.6	-6.8	2.9	17.7	23.3	5.2	-15.7	2.2	4.6	-12.9	-5.4

(Columns JAN–DEC: Deviations from Average Refractivity (N))

Spokane, Washington (SPOK)

Source	Day	Year	Hour	Refractivity (N) Mean	Refractivity (N) StDev	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
ECM	NA	NA	NA	327.3	6.7	-6.3	-7.2	-6.8	-0.8	4.9	12.4	8.1	6.7	0.3	0.1	-5.0	-6.4
HIRAS	NA	NA	0000	313.2	3.8	2.8	-1.3	-5.5	-4.4	-4.4	1.4	1.0	2.0	-4.3	3.0	4.7	4.7
			0600	322.0	5.2	-3.9	-5.2	-6.3	-4.8	-2.1	4.0	5.7	9.0	7.1	1.4	-1.9	-2.8
			1200	324.0	6.6	-6.2	-7.2	-5.7	-3.1	1.0	6.0	9.5	10.4	7.0	0.1	-5.8	-5.9
			1800	314.9	3.1	2.6	0.2	-3.2	-4.6	-5.0	-2.0	-0.1	1.1	0.3	3.4	3.3	4.2
MRF	1st	1995	0000	325.0	13.5	-7.9	5.7	-19.7	-1.8	-3.0	23.7	15.7	19.8	-11.6	-7.9	-10.5	-2.6
			0600	330.8	16.5	-21.6	1.1	-12.4	1.9	2.9	23.1	25.0	21.7	-2.6	-21.6	-15.4	-1.9
			1200	328.5	15.3	-14.7	-2.1	-15.2	-0.9	-4.3	10.7	27.0	27.0	5.5	-14.7	-16.4	-2.1
			1800	326.8	15.9	-17.9	-1.0	-10.6	4.4	4.0	14.0	22.5	31.1	-11.0	-17.9	-13.7	-3.9
MRF	15th	1995	0000	334.1	17.1	-3.6	-25.4	6.3	-15.4	5.5	25.2	7.8	-2.4	-29.4	21.5	13.9	-4.1
			0600	339.9	16.3	-10.7	-25.3	0.1	-16.9	23.8	16.1	16.7	3.2	-19.2	16.2	6.0	-10.0
			1200	333.8	14.3	-10.5	-23.1	-3.2	-21.4	8.5	15.2	12.8	8.9	-2.6	20.2	6.4	-11.3
			1800	335.1	14.1	-11.5	-20.9	-1.7	-11.5	17.9	16.5	-12.8	14.8	-4.7	18.1	6.2	-10.4
MRF	28th	1995	0000	326.4	13.6	-1.4	-20.4	-6.9	-4.8	12.8	12.6	3.4	-13.8	28.9	-6.1	6.2	-10.6
			0600	330.5	16.3	-6.4	-14.3	-6.4	-0.8	31.9	14.5	6.9	-19.9	24.0	-8.6	-3.6	-17.4
			1200	326.0	14.2	-4.2	-12.1	-4.8	-12.4	25.0	9.1	3.3	-7.6	28.0	-5.5	-2.4	-16.4
			1800	331.3	17.5	-6.9	-11.6	-1.9	-6.8	35.0	15.0	-2.0	-21.5	28.8	-11.4	-0.7	-16.0

(Columns JAN–DEC: Deviations from Average Refractivity (N))

Average Annual Surface Refractivities with Monthly Deviations for 10 Areas-of-Interest (Sources: ECM, HIRAS, and MRF Data)

Tehran, Iran (TEHRAN)

Source	Day	Year	Hour	Refractivity (N) Mean	Refractivity (N) StDev	Deviations from Average Refractivity (N) JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
ECM	NA	NA	NA	322.5	13.0	5.7	5.3	10.9	18.0	14.6	-8.2	-12.0	-20.4	-19.5	-7.5	5.4	7.8
HIRAS	NA	NA	0000	346.9	10.8	-15.7	-14.4	-10.2	0.2	-2.5	1.8	5.4	17.9	16.3	7.6	0.3	-6.8
			0600	347.8	14.2	-16.5	-18.5	-13.0	-4.3	-3.2	0.3	7.8	21.6	27.3	8.4	-1.6	-8.3
			1200	340.5	13.7	-15.8	-18.7	-13.7	-8.0	-4.6	4.6	15.1	20.7	19.7	5.4	4.5	-9.2
			1800	341.6	10.9	-10.7	-15.2	-11.2	-2.2	-6.4	-3.9	3.5	12.9	20.5	12.5	3.4	-3.2
MRF	1st	1995	0000	321.2	20.4	17.3	0.6	-8.5	-15.6	15.2	43.1	0.3	-33.1	-17.0	17.3	-8.3	-11.4
			0600	315.3	24.5	20.0	10.2	1.0	-11.5	24.8	35.9	-20.0	-53.1	-19.5	20.0	-7.8	0.1
			1200	296.3	29.1	32.1	15.8	13.9	-7.9	29.8	15.5	-40.8	-51.8	-33.7	32.1	-9.8	4.7
			1800	315.9	24.2	13.5	4.2	19.6	-4.6	26.5	25.9	-19.6	-60.5	-15.6	13.5	-0.9	-2.0
MRF	15th	1995	0000	324.0	23.5	-10.8	13.6	24.2	24.8	26.9	18.5	-39.8	11.0	-20.1	-4.6	-36.6	-7.2
			0600	313.0	32.2	-9.3	26.2	41.8	51.9	28.3	-1.2	-60.3	-6.2	-27.0	-7.6	-28.8	-8.0
			1200	298.7	37.6	19.5	41.9	56.3	41.8	34.3	-25.0	-54.0	-46.5	-30.0	-17.3	-19.5	-1.7
			1800	314.8	26.5	10.0	25.4	38.0	24.1	34.5	-2.6	-34.7	-35.7	-21.9	-11.5	-26.0	0.4
MRF	28th	1995	0000	318.9	18.6	-0.5	4.5	-0.9	21.7	20.4	13.6	-36.3	-27.4	20.4	-12.8	-7.2	4.5
			0600	305.5	24.1	12.7	15.6	7.4	22.5	33.9	2.5	-48.5	-37.3	-4.6	-13.5	-7.2	16.5
			1200	288.8	32.1	17.4	17.7	2.1	12.5	69.5	-18.6	-43.1	-42.1	-28.1	-11.6	-4.6	28.9
			1800	308.0	30.4	9.6	10.7	7.9	20.7	73.1	-18.4	-39.5	-35.8	-19.6	-11.9	-12.1	15.3

Xining, China (XINING)

Source	Day	Year	Hour	Refractivity (N) Mean	Refractivity (N) StDev	Deviations from Average Refractivity (N) JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
ECM	NA	NA	NA	342.2	21.2	-28.1	-24.1	-17.4	-7.4	13.9	21.1	26.3	21.2	24.5	7.3	-12.8	-24.5
HIRAS	NA	NA	0000	344.5	22.3	-25.3	-25.5	-18.5	-6.1	8.0	25.3	34.6	31.3	14.7	-0.9	-15.3	-22.3
			0600	343.1	24.4	-23.7	-28.7	-25.3	-12.4	1.0	22.0	39.9	37.8	19.2	1.0	-10.9	-19.9
			1200	348.1	25.1	-26.5	-28.9	-20.8	-6.1	3.1	21.1	36.7	41.8	20.1	3.0	-18.3	-25.2
			1800	336.6	19.5	-17.9	-24.8	-21.3	-10.9	1.0	16.9	32.6	29.6	14.5	0.3	-6.8	-13.2
MRF	1st	1995	0000	351.8	42.2	-29.3	-27.5	-39.1	-9.0	-14.7	35.0	0.7	72.4	87.4	-29.3	-16.4	-30.2
			0600	346.7	44.7	-22.7	-30.7	-38.4	2.0	-37.3	33.6	-11.0	85.5	86.1	-22.7	-13.5	-31.0
			1200	350.1	53.5	-34.0	-35.5	-38.5	-10.1	-42.3	36.7	-8.7	97.9	110.2	-34.0	-5.4	-36.3
			1800	346.3	44.7	-32.5	-26.0	-28.1	-9.4	-29.4	12.8	-8.4	79.1	100.3	-32.5	3.7	-29.6
MRF	15th	1995	0000	351.8	38.4	-28.9	-29.9	-24.7	-28.1	-19.4	48.4	49.3	65.8	38.0	-5.0	-34.7	-30.7
			0600	339.1	45.3	-40.3	-27.2	-34.7	-17.3	-44.4	42.7	47.4	89.9	47.4	1.9	-42.1	-23.5
			1200	340.0	39.8	-42.5	-28.1	-35.7	-19.5	-25.5	47.4	25.3	70.4	49.1	19.5	-37.3	-23.1
			1800	348.2	34.4	-36.2	-26.7	-24.6	-26.1	-3.2	41.3	46.9	42.2	38.7	14.8	-36.8	-30.3
MRF	28th	1995	0000	355.0	43.0	-32.0	-40.6	-24.8	-11.2	9.4	21.8	94.8	67.2	2.1	-14.5	-34.8	-37.4
			0600	334.6	43.8	-24.8	-33.5	-21.6	-11.6	25.8	-1.0	92.1	79.4	-5.7	-28.7	-36.1	-34.2
			1200	345.5	46.7	-27.7	-37.2	-18.9	-31.0	19.2	14.5	104.3	72.9	7.5	-28.8	-31.6	-43.3
			1800	354.7	45.4	-27.3	-37.5	-14.4	-29.7	3.4	28.6	97.4	64.4	24.7	-26.1	-32.8	-50.7

Appendix C

REFRACTIVITIES FOR HIGH ALTITUDE AREAS FOR 29 AREAS OF INTEREST BY SEASONS

Refractivities for high altitude areas above 1000 m from the mean sea level (MSL) are compared by seasons and continents with tropical separations.

Refractivity Averages
Areas-of-Interest with High Altitude Surface Pressures
(Altitude Source: MRF Data; Refractivity Source: ECM Data)

Area Name	Description	From Lat°	From Lon°	To Lat°	To Lon°	Climate	Continent	Height[1] Above MSL (m)	Refractivity (N) FEB	MAY	AUG	NOV
AHAGR	Ahaggar, Algeria	22.5	5.0	25.0	7.5	Subtropical	Africa	>1000	296.97	301.58	311.31	306.87
ECONGO	East Congo (Zaire)	-7.5	27.5	5.0	30.0	Tropical	Africa	>1000	383.77	397.35	380.19	396.18
IRKTSK	Irkutsk, Siberia	50.0	97.5	55.0	102.5	Boreal	Asia	>1000	316.56	325.45	350.66	316.10
NGUIN	New Guinea	-5.0	140.0	-2.5	142.5	Tropical	Asia	>1000	396.64	405.14	397.88	401.78
URALS	Ural Mountains	57.5	57.5	62.5	62.5	Boreal	Europe	>1000	316.79	316.46	337.46	313.75
PYRNES	Pyrenee Mountains	42.5	-2.5	45.0	2.5	Subtrop/Temp	Europe	>1000	325.48	337.69	357.56	334.15
ALPS	Alp Mountains	45.0	5.0	47.5	10.0	Temperate	Europe	>1000	321.43	340.60	357.37	328.55
ALBRTA	Alberta, Canada	52.5	-120.0	55.0	-115.0	Temperate	North America	>1000	313.32	328.10	344.67	316.38
AQUAS	Aguas, Mexico	22.5	-102.5	25.0	-100.0	Tropical	North America	>1000	340.36	359.21	387.61	357.93
SANTGO	Santiago, Chile	-32.5	-72.5	-30.0	-70.0	Subtropical	South America	>1000	338.72	333.77	328.63	332.04
QUITO	Quito, Ecuador	0.0	-77.5	2.5	-75.0	Tropical	South America	>1000	389.28	395.96	386.27	393.71
ETHIOP	Ethiopia	0.0	40.0	7.5	42.5	Tropical	Africa	>2000	350.88	383.90	365.65	371.91
GOBI	Gobi Desert	37.5	85.0	47.5	112.5	Temperate	Asia	>2000	311.15	319.40	336.89	313.51
KABUL	Kabul, Afghanistan	32.5	65.0	35.0	67.5	Subtropical	Asia	>2000	324.27	325.46	320.91	319.24
TEHRAN	Tehran, Iran	32.5	50.0	35.0	52.5	Subtropical	Asia	>2000	324.63	341.59	311.56	328.07
LNZHU	Lanzhou, China	35.0	100.0	37.5	102.5	Temperate	Asia	>2000	312.84	345.12	360.75	321.60
GRNLN	Greenland (North)	72.5	-40.0	80.0	-30.0	Polar	Greenland	>2000	312.40	312.79	317.91	311.13
GRNLS	Greenland (South)	62.5	-50.0	67.5	-40.0	Polar	Greenland	>2000	306.46	316.18	321.91	307.93
SPOK	Spokane, Washington	47.5	-120.0	50.0	-117.5	Temperate	North America	>2000	321.40	329.75	334.85	320.62
CSCO	Colorado Springs, Colorado	37.5	-107.5	40.0	-105.0	Temperate	North America	>2000	321.35	339.85	340.14	322.19
ANTHI	Antartica	-85.0	10.0	-72.5	122.5	Polar	Antarctic	>3000	308.31	322.95	325.89	309.49
XINING	Xining, China	35.0	102.5	37.5	105.0	Temperate	Asia	>3000	311.60	339.47	361.64	323.44
HAAM	Himalayas	32.5	-115.0	42.5	-102.5	Temperate	Asia	>3000	317.14	329.60	347.27	317.84
GRNLHI	Greenland	67.5	-40.0	70.0	-35.0	Polar	Greenland	>3000	306.51	314.04	319.17	307.75
HUANCO	Huancayo, Peru	-12.5	-75.0	-10.0	-72.5	Tropical	South America	>3000	383.66	385.74	375.06	386.73
TANGMI	Tangmai, Tibet	27.5	92.5	30	100	Temperate	Asia	>4000	333.48	371.64	381.03	347.37
LAPAZ	LaPaz, Bolivia	-20	-70	-15	-67.5	Tropical	South America	>4000	368.77	364.51	356.35	362.27
KASHMR	Kashmir, India	32.5	75.0	35.0	77.5	Temperate	Asia	>5000	324.73	356.31	373.40	333.12
LHASA	Lhasa, Tibet	30.0	90.0	32.5	92.5	Temperate	Asia	>5000	317.59	349.41	366.56	325.94

(1) Height above mean-sea-level at which surface pressure occurs.

Appendix D

FIRST AND SECOND ORDER REFRACTIVITY GRADIENTS FOR 12 AREAS OF INTEREST

First- and second-order refractivity gradients are compared for 12 areas of interest by months with European Center for Medium-Range Weather Forecast (ECM) and High-Resolution Analysis System (HIRAS) databases. It is noticed that the second-order refractivity gradients are good sources for distinction from normal refractivity, and they are easily comparable with other areas, months, and seasons.

DATABASE: ECM First Order Refractivity Gradients (1000mb - 850mb)

AOI	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
CAN	47.82	47.83	48.26	50.36	53.47	56.86	60.63	60.82	56.62	52.12	48.14	47.72
CAM	83.98	83.88	85.63	87.77	88.12	89.49	92.37	92.27	89.89	86.99	86.41	85.50
AMFOR	81.25	80.47	82.11	83.84	82.74	81.63	78.83	78.80	79.65	81.64	81.69	81.98
SAF	72.63	73.31	74.01	74.63	72.11	67.96	66.05	65.43	65.77	67.76	69.35	71.82
SAH	46.36	44.81	45.44	49.78	56.74	61.00	64.23	66.92	65.16	58.73	54.10	49.58
AUS	69.67	71.02	69.94	69.49	67.96	66.93	64.50	63.34	64.26	65.82	67.65	69.82
SEAS1	83.60	84.33	86.94	93.00	94.07	91.37	89.34	89.03	89.84	89.42	86.28	83.84
SEAS2	84.03	85.52	89.42	92.07	91.90	89.59	88.55	88.55	88.81	88.81	87.14	84.43
GOBI	43.51	43.48	44.83	47.32	51.59	55.43	56.85	56.38	51.58	47.42	45.74	44.27
EURAS	47.70	48.01	49.32	53.67	57.13	60.68	60.56	57.87	55.79	51.68	49.34	48.57
SIB	50.45	50.05	48.91	47.60	47.78	52.07	54.66	53.95	49.84	46.12	47.25	49.17
NAK	46.71	48.00	49.29	51.30	51.11	50.59	48.32	52.82	57.70	55.55	51.95	48.33

DATABASE: ECM First Order Refractivity Gradients (850mb - 700mb))

AOI	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
CAN	44.66	44.34	43.90	44.37	47.69	51.89	55.88	55.19	50.97	47.67	45.69	44.87
CAM	67.43	68.03	67.66	67.51	71.67	70.89	68.95	68.78	69.67	70.13	71.06	68.89
AMFOR	71.07	71.66	71.10	71.14	72.35	70.24	68.48	68.84	69.45	70.81	72.05	71.79
SAF	59.06	60.32	60.29	58.90	55.87	54.41	52.80	52.32	53.95	54.36	56.34	58.09
SAH	48.50	45.34	44.05	46.04	48.62	52.19	57.32	60.51	56.60	53.34	51.13	49.28
AUS	58.54	59.64	59.16	56.65	56.94	53.50	52.49	52.61	51.21	52.37	54.55	56.22
SEAS1	69.26	68.50	68.71	68.26	69.21	69.60	70.63	69.82	69.13	70.15	69.85	70.11
SEAS2	70.09	68.94	67.63	69.41	70.96	70.75	68.80	67.69	67.32	68.76	70.52	69.92
GOBI	44.80	44.36	44.55	45.46	47.99	50.03	52.47	52.76	49.02	46.08	45.26	45.50
EURAS	44.47	44.01	44.32	45.91	49.23	52.42	54.68	53.42	49.14	47.16	45.65	45.35
SIB	43.97	43.71	42.97	42.59	43.83	47.31	51.13	49.95	46.50	44.09	44.00	43.98
NAK	45.53	45.51	45.57	45.58	47.80	50.70	55.87	56.74	51.51	48.93	47.49	46.49

DATABASE: ECM Second Order Refractivity Gradients [(1000mb - 850mb) - (850mb - 700mb)]

AOI	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
CAN	3.16	3.48	4.36	5.99	5.78	4.97	4.75	5.63	5.65	4.45	2.45	2.85
CAM	16.55	15.84	17.96	20.26	16.45	18.60	23.42	23.50	20.22	16.86	15.35	16.62
AMFOR	10.18	8.81	11.00	12.70	10.38	11.39	10.35	9.97	10.20	10.83	9.64	10.19
SAF	13.57	12.99	13.73	15.73	16.23	13.55	13.25	13.10	11.82	13.40	13.01	13.73
SAH	-2.14	-0.53	1.40	3.74	8.12	8.81	6.91	6.41	8.57	5.40	2.97	0.30
AUS	11.13	11.38	10.78	12.85	11.01	13.43	12.01	10.74	13.05	13.44	13.10	13.61
SEAS1	14.34	15.83	18.23	24.74	24.86	21.77	18.71	19.21	20.71	19.27	16.43	13.73
SEAS2	13.94	16.57	21.79	22.65	20.93	18.84	19.75	20.86	21.49	20.05	16.62	14.51
GOBI	-1.30	-0.88	0.28	1.86	3.60	5.40	4.38	3.62	2.56	1.35	0.49	-1.24
EURAS	3.22	4.01	5.00	7.76	7.90	8.26	5.87	4.45	6.65	4.52	3.69	3.22
SIB	6.48	6.34	5.95	5.01	3.95	4.77	3.53	4.00	3.34	2.03	3.25	5.19
NAK	1.18	2.49	3.72	5.71	3.31	-0.12	-7.55	-3.92	6.19	6.62	4.46	1.84

DATABASE: HIRAS First Order Refractivity Gradients (1000mb - 850mb) 6.50

AOI	HR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
CAN	00	46.54	45.57	44.85	45.38	47.28	51.37	54.66	55.84	53.90	49.86	47.37	46.77
CAN	06	46.39	46.08	46.10	47.21	49.98	54.58	58.99	59.52	55.92	51.09	47.75	46.66
CAN	12	47.25	47.38	47.56	48.74	51.90	55.82	59.40	60.74	56.72	51.58	47.40	47.16
CAN	18	46.30	46.09	46.14	46.68	48.90	52.51	56.67	57.53	54.43	50.25	47.40	46.61
CAM	00	82.62	82.81	84.83	83.87	81.81	82.00	81.98	82.31	82.08	81.94	81.70	82.37
CAM	06	83.01	84.13	85.40	85.71	86.04	87.19	88.04	87.04	85.95	84.04	83.17	83.49
CAM	12	80.13	80.63	83.13	83.23	83.14	82.88	83.60	83.12	81.50	80.61	75.10	80.10
CAM	18	74.44	75.52	76.28	76.36	77.30	78.96	79.45	78.70	78.04	75.49	75.10	74.75
AMFOR	00	68.12	67.79	69.79	70.56	73.79	76.58	77.94	79.40	77.99	75.75	73.55	69.96
AMFOR	06	66.28	65.83	66.40	67.13	69.98	74.13	76.92	78.87	77.42	75.33	72.15	68.72
AMFOR	12	70.83	71.14	72.76	72.08	73.15	74.96	75.33	76.47	76.15	75.60	62.03	71.90
AMFOR	18	58.82	58.35	58.89	59.41	61.54	65.04	65.60	66.08	64.72	63.50	62.03	59.79
SAF	00	73.94	71.66	72.63	69.61	67.09	61.74	62.56	63.16	65.88	65.38	69.19	70.60
SAF	06	67.37	65.46	66.83	64.01	63.33	59.20	60.95	61.78	62.77	62.04	64.48	64.58
SAF	12	72.04	71.03	71.45	69.06	67.60	60.39	61.76	62.56	65.98	65.54	62.90	69.70
SAF	18	62.95	60.92	62.73	61.03	60.83	57.72	58.74	59.73	61.00	60.84	62.90	61.39
SAH	00	71.43	71.02	69.80	69.38	74.65	80.65	82.83	83.49	85.56	77.72	71.97	69.88
SAH	06	72.99	71.71	70.11	67.88	72.32	77.82	80.67	81.97	83.24	76.93	71.90	71.32
SAH	12	67.50	65.95	64.47	62.30	66.37	71.93	72.16	74.03	75.66	69.97	69.48	65.39
SAH	18	70.80	70.05	68.30	65.05	68.22	72.11	74.21	76.69	78.40	72.66	69.48	69.28
AUS	00	67.22	67.82	66.20	62.25	59.62	59.01	58.19	58.31	60.67	63.74	65.30	68.12
AUS	06	58.40	58.40	57.22	55.55	55.82	57.14	56.78	56.43	57.57	58.92	59.65	59.38
AUS	12	62.96	63.28	62.51	59.60	59.15	59.78	59.19	59.20	60.18	62.75	59.33	63.52
AUS	18	58.69	57.86	57.89	57.00	56.93	58.44	57.87	58.10	58.43	59.25	59.33	58.70
SEAS1	00	74.11	76.80	79.50	81.78	80.32	79.58	77.95	76.88	77.13	76.98	74.65	71.86
SEAS1	06	61.29	63.80	65.87	68.23	67.89	70.11	68.74	68.32	68.27	67.35	64.87	60.72
SEAS1	12	70.14	72.26	74.48	77.27	77.14	76.55	75.21	75.03	74.86	74.14	69.78	68.86
SEAS1	18	66.76	69.89	73.05	75.77	75.21	75.88	74.10	73.53	74.07	72.83	69.78	65.91
SEAS2	00	75.02	76.71	77.43	79.26	79.07	79.13	78.25	78.51	78.64	77.42	75.47	74.29
SEAS2	06	61.43	63.12	63.76	65.73	67.34	69.75	68.27	68.72	67.93	66.34	64.03	61.21
SEAS2	12	73.33	75.72	77.01	79.40	79.54	79.95	79.48	79.40	78.77	77.52	72.11	73.26
SEAS2	18	68.43	70.45	72.12	75.16	76.81	78.37	77.89	77.97	77.77	75.50	72.11	68.41
GOBI	00	46.05	44.72	43.91	45.97	51.97	59.37	64.01	65.60	58.77	52.61	46.94	46.13
GOBI	06	44.59	43.39	42.46	43.52	47.77	53.12	59.54	61.45	54.06	50.02	46.25	45.26
GOBI	12	44.28	42.43	42.07	43.90	51.45	59.20	65.79	69.95	62.21	52.98	46.89	44.96
GOBI	18	45.00	43.44	42.97	44.48	48.78	54.52	59.84	62.30	56.47	52.33	46.89	45.63
EURAS	00	47.25	47.54	48.99	52.01	56.46	63.84	67.02	64.54	59.00	53.72	49.78	48.29
EURAS	06	46.74	46.76	47.93	49.43	51.68	58.47	62.04	60.36	55.73	51.66	49.23	47.91
EURAS	12	46.31	45.90	45.88	45.51	47.28	53.65	56.41	55.51	51.61	48.74	49.13	47.55
EURAS	18	46.79	46.74	47.64	49.09	52.14	58.13	61.87	60.80	55.89	51.71	49.13	47.90
SIB	00	50.04	49.09	47.11	45.44	45.37	49.43	54.20	52.73	48.45	44.69	47.05	48.78
SIB	06	47.88	47.04	45.19	43.86	44.04	47.19	51.54	50.36	46.97	44.18	45.61	46.88
SIB	12	49.66	48.70	46.03	44.13	44.68	48.76	52.71	52.07	48.07	44.44	46.14	48.77
SIB	18	48.64	47.64	45.91	44.70	45.84	50.59	55.77	53.92	48.84	44.60	46.14	47.56
NAK	00	45.46	45.86	45.65	47.39	49.56	52.60	54.77	56.92	53.62	50.59	47.45	46.11
NAK	06	44.95	45.16	45.27	47.00	49.33	53.30	57.01	57.79	53.05	49.60	46.76	45.59
NAK	12	45.42	45.60	45.74	47.54	50.20	52.99	54.72	57.57	54.06	50.66	46.81	45.95
NAK	18	44.97	45.04	45.28	47.39	49.84	53.60	56.60	58.28	53.34	49.92	46.81	45.83

DATABASE: HIRAS First Order Refractivity Gradients (850mb - 700mb))

AOI	HR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
CAN	00	44.47	44.15	43.48	43.55	45.27	49.20	52.42	52.60	49.09	46.12	44.85	44.35
CAN	06	44.35	44.15	44.13	44.99	47.91	52.72	56.51	56.05	51.10	46.97	45.02	44.24
CAN	12	44.54	44.36	44.05	44.68	46.74	50.40	53.39	53.18	49.92	46.63	44.56	44.33
CAN	18	44.11	43.76	43.27	43.04	44.02	46.79	49.16	48.81	46.71	45.13	44.56	43.96
CAM	00	64.24	64.36	64.54	65.78	67.18	67.91	68.48	68.51	67.92	67.78	68.39	66.33
CAM	06	66.95	66.29	67.60	70.07	72.52	73.54	73.90	73.49	72.43	71.27	70.91	67.85
CAM	12	68.92	68.79	69.21	69.84	70.19	71.17	71.06	70.47	69.42	69.09	66.18	69.99
CAM	18	63.30	62.54	62.48	64.42	66.35	67.97	67.20	67.20	67.02	65.88	66.18	63.61
AMFOR	00	69.43	69.15	70.42	71.56	71.00	67.72	64.40	64.59	66.07	67.72	69.42	69.95
AMFOR	06	77.66	77.33	79.43	80.93	79.98	75.48	71.78	72.83	75.11	77.25	78.55	78.27
AMFOR	12	69.18	69.33	70.18	70.59	70.28	67.76	64.70	64.81	65.75	66.96	67.24	68.73
AMFOR	18	69.15	69.37	69.93	70.70	69.05	65.17	61.20	60.45	62.30	64.88	67.24	68.74
SAF	00	57.61	60.55	58.73	55.10	52.75	52.18	51.63	52.35	53.21	55.31	55.73	58.17
SAF	06	63.62	66.64	64.75	59.79	56.76	54.04	53.42	54.44	56.03	57.77	59.28	62.50
SAF	12	57.80	61.12	59.16	53.87	51.55	50.93	50.44	51.52	51.88	54.26	60.96	57.70
SAF	18	64.67	68.07	66.60	61.60	59.26	55.74	55.80	56.51	57.04	58.63	60.96	63.86
SAH	00	47.93	46.23	45.42	44.86	46.10	45.69	49.48	51.74	49.10	47.69	49.16	49.01
SAH	06	47.62	45.71	45.04	45.01	46.06	46.78	50.18	51.67	49.50	48.98	49.52	49.09
SAH	12	45.17	43.43	42.69	41.93	42.77	43.56	46.62	48.59	45.89	44.22	47.29	46.05
SAH	18	44.99	43.65	43.47	43.61	44.40	44.63	47.31	49.34	47.24	46.54	47.29	46.64
AUS	00	58.00	58.47	57.40	57.01	57.70	56.63	54.93	52.89	52.84	52.30	54.89	56.01
AUS	06	63.41	64.62	63.45	61.57	59.51	56.81	54.79	53.52	54.72	55.35	58.75	60.80
AUS	12	63.16	63.54	62.43	60.65	59.08	56.85	55.59	54.27	55.22	55.90	61.66	60.94
AUS	18	66.74	67.77	66.57	63.68	60.21	57.10	55.54	54.95	57.10	58.54	61.66	64.11
SEAS1	00	71.15	70.63	71.54	72.84	72.96	71.76	69.96	70.38	70.54	71.01	70.48	71.68
SEAS1	06	69.14	68.68	69.54	71.88	72.76	71.51	69.41	70.20	70.29	69.92	68.95	68.73
SEAS1	12	69.75	69.06	70.10	70.30	71.24	70.39	69.11	69.15	69.47	70.05	75.31	70.51
SEAS1	18	76.17	76.53	78.30	79.76	79.63	77.36	75.32	75.22	75.66	75.83	75.31	74.97
SEAS2	00	72.53	72.99	72.87	72.96	73.37	71.25	69.69	69.16	69.05	70.08	71.91	72.35
SEAS2	06	71.56	71.37	71.72	72.63	73.24	70.51	68.67	68.07	68.22	69.85	71.62	71.68
SEAS2	12	74.59	74.41	75.35	75.42	75.36	72.83	71.06	70.74	70.82	72.72	80.48	74.86
SEAS2	18	79.38	80.03	81.41	83.07	82.53	79.65	77.94	77.02	77.96	79.51	80.48	79.82
GOBI	00	46.49	44.60	43.84	43.46	45.78	51.96	57.77	57.06	50.72	46.64	45.94	46.65
GOBI	06	44.01	42.48	41.72	40.99	43.04	47.49	54.68	54.28	47.29	43.87	43.57	44.49
GOBI	12	44.52	41.58	40.05	38.00	40.01	44.67	49.46	48.88	44.57	42.46	44.18	45.15
GOBI	18	43.95	42.03	41.32	40.55	42.55	46.43	51.51	51.34	47.28	45.22	44.18	44.55
EURAS	00	45.00	44.44	44.71	46.41	48.49	51.97	54.70	54.05	50.41	47.02	45.34	45.22
EURAS	06	44.57	44.08	43.93	44.07	44.68	47.04	49.63	49.65	46.90	45.13	44.81	44.93
EURAS	12	44.74	43.97	43.88	44.29	45.44	48.12	50.71	50.04	47.55	45.20	45.52	44.97
EURAS	18	44.76	44.33	44.91	46.97	49.80	54.44	57.31	56.45	51.69	47.59	45.52	45.20
SIB	00	44.54	44.28	43.76	43.46	44.44	46.89	50.23	49.36	46.30	44.21	44.01	44.31
SIB	06	44.95	44.69	43.76	43.00	43.56	45.60	48.36	47.41	44.99	43.80	44.17	44.63
SIB	12	44.39	44.17	43.56	43.14	44.18	46.73	49.94	49.10	46.24	44.10	44.03	44.20
SIB	18	44.67	44.33	43.85	43.64	45.09	48.78	52.89	50.98	46.78	44.17	44.03	44.33
NAK	00	44.91	45.43	45.66	46.22	48.16	49.88	54.13	54.92	51.83	48.75	47.01	45.94
NAK	06	44.53	44.85	45.25	45.85	48.12	50.67	55.03	55.67	51.91	48.35	46.34	45.41
NAK	12	44.72	45.11	45.57	45.96	48.14	50.15	54.29	54.73	52.28	49.00	46.14	45.80
NAK	18	44.40	44.72	45.07	45.72	47.96	50.37	54.64	55.06	51.53	48.33	46.14	45.33

DATABASE: HIRAS Second Order Refractivity Gradients [(1000mb - 850mb) - (850mb - 700mb)]

AOI	HR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
CAN	00	2.07	1.42	1.37	1.83	2.01	2.18	2.24	3.24	4.81	3.73	2.52	2.42
CAN	06	2.04	1.93	1.97	2.21	2.06	1.86	2.48	3.47	4.82	4.13	2.73	2.42
CAN	12	2.70	3.02	3.51	4.07	5.16	5.42	6.01	7.56	6.80	4.94	2.84	2.83
CAN	18	2.19	2.33	2.87	3.63	4.88	5.72	7.51	8.72	7.72	5.12	2.84	2.65
CAM	00	18.38	18.45	20.29	18.09	14.63	14.09	13.50	13.79	14.15	14.16	13.31	16.04
CAM	06	16.06	17.85	17.80	15.64	13.52	13.65	14.14	13.55	13.52	12.77	12.25	15.64
CAM	12	11.22	11.84	13.92	13.39	12.95	11.71	12.54	12.65	12.08	11.51	8.93	10.11
CAM	18	11.14	12.97	13.80	11.94	10.95	10.99	12.25	11.50	11.02	9.60	8.93	11.14
AMFOR	00	-1.30	-1.36	-0.64	-1.00	2.79	8.86	13.54	14.81	11.92	8.03	4.14	0.01
AMFOR	06	-11.38	-11.51	-13.03	-13.80	-10.00	-1.35	5.14	6.04	2.31	-1.92	-6.39	-9.55
AMFOR	12	1.65	1.82	2.58	1.49	2.86	7.21	10.62	11.66	10.40	8.64	-5.21	3.18
AMFOR	18	-10.33	-11.02	-11.05	-11.29	-7.51	-0.13	4.39	5.63	2.42	-1.38	-5.21	-8.94
SAF	00	16.33	11.11	13.90	14.51	14.33	9.55	10.93	10.81	12.67	10.07	13.45	12.43
SAF	06	3.76	-1.18	2.08	4.22	6.57	5.16	7.53	7.34	6.74	4.27	5.20	2.08
SAF	12	14.24	9.91	12.30	15.19	16.06	9.45	11.33	11.04	14.10	11.28	1.94	12.00
SAF	18	-1.72	-7.15	-3.87	-0.58	1.57	1.99	2.94	3.21	3.96	2.21	1.94	-2.47
SAH	00	23.50	24.78	24.38	24.52	28.55	34.96	33.35	31.75	36.45	30.03	22.81	20.87
SAH	06	25.37	26.00	25.07	22.87	26.25	31.04	30.50	30.30	33.74	27.95	22.38	22.24
SAH	12	22.33	22.53	21.77	20.37	23.60	28.37	25.54	25.44	29.77	25.76	22.20	19.33
SAH	18	25.82	26.40	24.83	21.44	23.82	27.48	26.90	27.35	31.16	26.12	22.20	22.64
AUS	00	9.22	9.35	8.80	5.24	1.92	2.38	3.26	5.42	7.83	11.44	10.41	12.12
AUS	06	-5.02	-6.23	-6.23	-6.02	-3.69	0.32	2.00	2.91	2.85	3.56	0.90	-1.42
AUS	12	-0.21	-0.27	0.07	-1.04	0.07	2.92	3.61	4.93	4.96	6.84	-2.33	2.58
AUS	18	-8.04	-9.90	-8.68	-6.68	-3.28	1.34	2.33	3.15	1.33	0.71	-2.33	-5.42
SEAS1	00	2.96	6.17	7.96	8.94	7.36	7.82	7.98	6.51	6.59	5.97	4.18	0.18
SEAS1	06	-7.85	-4.88	-3.67	-3.66	-4.87	-1.40	-0.67	-1.89	-2.02	-2.57	-4.09	-8.01
SEAS1	12	0.39	3.20	4.38	6.97	5.90	6.16	6.10	5.88	5.39	4.09	-5.52	-1.65
SEAS1	18	-9.42	-6.64	-5.25	-3.99	-4.42	-1.48	-1.22	-1.70	-1.59	-3.00	-5.52	-9.06
SEAS2	00	2.49	3.71	4.56	6.29	5.70	7.88	8.57	9.35	9.59	7.34	3.55	1.94
SEAS2	06	-10.13	-8.25	-7.96	-6.91	-5.90	-0.76	-0.40	0.65	-0.29	-3.51	-7.58	-10.48
SEAS2	12	-1.26	1.31	1.67	3.98	4.17	7.12	8.42	8.66	7.95	4.80	-8.37	-1.60
SEAS2	18	-10.95	-9.58	-9.29	-7.91	-5.72	-1.29	-0.04	0.94	-0.18	-4.01	-8.37	-11.41
GOBI	00	-0.44	0.11	0.08	2.51	6.19	7.40	6.24	8.54	8.05	5.97	1.00	-0.52
GOBI	06	0.57	0.91	0.74	2.53	4.73	5.63	4.86	7.17	6.78	6.14	2.68	0.77
GOBI	12	-0.24	0.85	2.01	5.90	11.45	14.53	16.33	21.08	17.64	10.52	2.71	-0.19
GOBI	18	1.05	1.42	1.64	3.93	6.22	8.09	8.34	10.97	9.19	7.11	2.71	1.08
EURAS	00	2.25	3.10	4.28	5.60	7.97	11.87	12.32	10.49	8.59	6.70	4.44	3.07
EURAS	06	2.17	2.67	4.00	5.36	7.01	11.43	12.41	10.71	8.83	6.54	4.42	2.98
EURAS	12	1.57	1.93	2.00	1.21	1.85	5.54	5.70	5.46	4.06	3.53	3.61	2.58
EURAS	18	2.02	2.41	2.73	2.12	2.34	3.69	4.56	4.35	4.20	4.12	3.61	2.70
SIB	00	5.51	4.81	3.35	1.98	0.92	2.55	3.97	3.37	2.15	0.48	3.04	4.47
SIB	06	2.93	2.34	1.43	0.86	0.48	1.59	3.18	2.94	1.98	0.39	1.45	2.25
SIB	12	5.27	4.53	2.47	0.99	0.50	2.03	2.77	2.96	1.83	0.35	2.11	4.57
SIB	18	3.97	3.31	2.06	1.06	0.75	1.81	2.88	2.94	2.05	0.43	2.11	3.22
NAK	00	0.54	0.44	-0.01	1.18	1.40	2.72	0.64	2.00	1.78	1.84	0.43	0.16
NAK	06	0.42	0.31	0.02	1.15	1.21	2.63	1.98	2.13	1.14	1.26	0.42	0.18
NAK	12	0.70	0.49	0.17	1.58	2.06	2.84	0.42	2.84	1.78	1.66	0.67	0.14
NAK	18	0.57	0.32	0.21	1.67	1.88	3.23	1.96	3.21	1.81	1.59	0.67	0.50

Appendix E

ELECTRONIC COUNTERMEASURES AND HIGH-RESOLUTION ANALYSIS SYSTEM DATABASES WORLDWIDE TIME DELAYS BY SEASONS AND MODELS

Global time delays for electronic countermeasures and high-resolution analysis system databases are compared for each model by seasons and elevation angles from the horizon (0°) to the zenith (90°). Note that the stratified model represents the empirical data supplied by the Environmental Technical Applications Center (Scott Air Force Base).

TIME DELAY: ECM Data Global Winter

Elev Ang (deg)	Stratified (ns)	Hopfield (ns)	Goad (ns)	Blake (ns)	Case1 (ns)	Cains (ns)	Choi (ns)
0.1	359.4677	282.2441	284.1863	345.7371	271.6648	283.8239	363.2622
0.5	305.9143	242.6092	244.4606	277.3366	232.7362	246.8413	311.4307
1.0	253.2324	204.4954	206.0520	219.9158	196.3543	210.9880	259.4160
3.0	140.9563	119.3441	120.3625	115.6715	116.6830	128.6369	145.5854
5.0	94.5656	81.4883	82.2334	76.4959	79.9267	89.3642	97.8481
7.0	70.4243	61.2371	61.7209	56.5391	59.9972	67.0020	72.9238
10.0	50.6533	44.2231	44.6220	40.6301	43.7459	47.5619	52.4780
20.0	26.2219	22.9834	23.2001	20.9653	23.2593	22.5154	27.1787
30.0	18.0048	15.7738	15.9439	14.3706	16.1590	14.2234	18.6635
50.0	11.7751	10.4652	10.4315	9.4026	11.1379	8.2859	12.2065
90.0	9.0250	8.1914	7.9969	7.2066	9.2428	5.8546	9.3558

TIME DELAY: ECM Data Global Spring

Elev Ang (deg)	Stratified (ns)	Hopfield (ns)	Goad (ns)	Blake (ns)	Case1 (ns)	Cains (ns)	Choi (ns)
0.1	361.6662	282.8062	286.1367	347.7041	271.6648	285.7526	365.0867
0.5	307.5152	242.8188	246.0119	278.9719	232.7362	248.5187	312.7799
1.0	254.3268	204.3608	207.2844	221.0621	196.3543	212.4218	260.3187
3.0	141.3482	119.1655	121.0511	115.8339	116.6830	129.5110	145.8127
5.0	94.7857	81.3153	82.7132	76.5578	79.9267	89.9715	97.9306
7.0	70.5756	61.0267	62.0867	56.6577	59.9972	67.4573	72.9627
10.0	50.7563	44.1317	44.8900	40.6878	43.7459	47.8851	52.4952
20.0	26.2728	22.8692	23.3413	20.9332	23.2593	22.6684	27.1830
30.0	18.0397	15.7572	16.0412	14.3775	16.1590	14.3200	18.6661
50.0	11.7977	10.3135	10.4953	9.3957	11.1379	8.3422	12.2078
90.0	9.0427	7.7960	8.0458	7.1956	9.2428	5.8944	9.3572

TIME DELAY: ECM Data Global Summer

Elev Ang (deg)	Stratified (ns)	Hopfield (ns)	Goad (ns)	Blake (ns)	Case1 (ns)	Cains (ns)	Choi (ns)
0.1	365.5481	284.9543	291.0744	351.3684	271.6648	288.4892	368.1594
0.5	310.8517	244.0105	249.8828	280.9103	232.7362	250.8987	315.2310
1.0	257.1037	204.7333	210.3048	222.3561	196.3543	214.4561	262.1916
3.0	142.8515	119.0109	122.6588	116.2637	116.6830	130.7513	146.5884
5.0	95.7856	81.0614	83.8117	76.6866	79.9267	90.8331	98.3762
7.0	71.3182	60.8016	62.9174	56.7275	59.9972	68.1033	73.2699
10.0	51.2897	43.8671	45.4953	40.6268	43.7459	48.3437	52.7044
20.0	26.5487	22.9358	23.6587	20.9954	23.2593	22.8855	27.2862
30.0	18.2289	15.7214	16.2597	14.4020	16.1590	14.4572	18.7361
50.0	11.9215	10.4310	10.6384	9.4151	11.1379	8.4221	12.2534
90.0	9.1375	7.9780	8.1555	7.2032	9.2428	5.9508	9.3920

TIME DELAY: ECM Data Global Fall

Elev Ang (deg)	Stratified (ns)	Hopfield (ns)	Goad (ns)	Blake (ns)	Case1 (ns)	Cains (ns)	Choi (ns)
0.1	361.8191	283.6215	288.1969	347.6079	271.6648	285.7486	365.1808
0.5	307.6799	243.2807	247.6303	278.8802	232.7362	248.5152	312.8873
1.0	254.4999	204.5126	208.5501	221.1560	196.3543	212.4188	260.4361
3.0	141.4901	119.0576	121.7280	115.9426	116.6830	129.5092	145.9060
5.0	94.8907	81.2824	83.1762	76.5301	79.9267	89.9702	97.9976
7.0	70.6561	60.9764	62.4369	56.6918	59.9972	67.4564	73.0135
10.0	50.8152	43.9709	45.1452	40.6448	43.7459	47.8845	52.5321
20.0	26.3036	22.9531	23.4751	20.9666	23.2593	22.6681	27.2022
30.0	18.0608	15.7312	16.1333	14.3764	16.1590	14.3198	18.6792
50.0	11.8116	10.2493	10.5556	9.3999	11.1379	8.3421	12.2165
90.0	9.0531	7.9272	8.0921	7.1951	9.2428	5.8943	9.3636

TIME DELAY: HIRAS Data Global Winter 0000Hrs

Elev Ang (deg)	Stratified (ns)	Hopfield (ns)	Goad (ns)	Blake (ns)	Case1 (ns)	Cains (ns)	Choi (ns)
0.1	349.0988	280.0612	280.5316	332.5566	271.6648	273.9586	353.7179
0.3	323.0476	259.4175	259.8922	297.8669	250.8466	255.0432	327.9562
0.5	299.1890	241.1270	241.5434	269.1526	232.7362	238.2615	304.3013
0.7	277.6505	224.8255	225.1690	244.9216	216.8431	223.2881	282.8752
0.9	258.2455	210.1097	210.5039	224.1660	202.7881	209.8590	263.5101
1.0	249.2871	203.4375	203.7411	215.2747	196.3543	203.6544	254.5492
2.0	181.5143	151.7874	151.9403	150.8135	147.6423	155.5860	186.3082
3.0	140.0722	119.0416	119.1164	114.4535	116.6830	124.1657	144.2007
4.0	112.9699	97.0280	97.0200	91.6188	95.3896	102.2637	116.5183
5.0	94.1737	81.2827	81.3874	75.7559	79.9267	86.2581	97.2533
6.0	80.5065	69.8238	69.8663	64.6466	68.5224	74.1300	83.2109
7.0	70.1862	61.0630	61.0845	56.2554	59.9972	64.6731	72.5883
8.0	62.1504	54.0982	54.2010	49.6943	53.3713	57.1258	64.3062
9.0	55.7343	48.6567	48.6786	44.5539	48.0750	50.9856	57.6866
10.0	50.5052	44.2180	44.1604	40.3969	43.7459	45.9088	52.2875
20.0	26.1547	22.9453	22.9592	20.8378	23.2593	21.7328	27.1022

TIME DELAY: HIRAS Data Global Winter 0600Hrs

Elev Ang (deg)	Stratified (ns)	Hopfield (ns)	Goad (ns)	Blake (ns)	Case1 (ns)	Cains (ns)	Choi (ns)
0.1	348.4777	279.9381	280.5132	331.9518	271.6648	273.3003	353.0928
0.3	322.5948	259.2990	259.8777	297.2939	250.8466	254.4303	327.4123
0.5	298.8686	241.0135	241.5324	268.7755	232.7362	237.6889	303.8303
0.7	277.4278	224.7171	225.1610	244.1612	216.8431	222.7515	282.4677
0.9	258.0951	210.0059	210.4985	224.1458	202.7881	209.3547	263.1573
1.0	249.1653	203.3364	203.7369	214.8691	196.3543	203.1651	254.2207
2.0	181.5250	151.7076	151.9438	150.6010	147.6423	155.2121	186.1394
3.0	140.1081	118.9774	119.1231	114.3727	116.6830	123.8673	144.1038
4.0	113.0084	96.9751	97.0276	91.4194	95.3896	102.0180	116.4568
5.0	94.2098	81.2374	81.3951	75.6459	79.9267	86.0508	97.2108
6.0	80.5392	69.7849	69.8738	64.5407	68.5224	73.9519	83.1795
7.0	70.2158	61.0289	61.0915	56.0652	59.9972	64.5177	72.5640
8.0	62.1773	54.0675	54.2076	49.7020	53.3713	56.9885	64.2865
9.0	55.7588	48.6294	48.6847	44.4791	48.0750	50.8630	57.6702
10.0	50.5276	44.1935	44.1661	40.3326	43.7459	45.7984	52.2734
20.0	26.1667	22.9323	22.9624	20.8415	23.2593	21.6806	27.0964

TIME DELAY: HIRAS Data Global Winter 1200Hrs

Elev Ang (deg)	Stratified (ns)	Hopfield (ns)	Goad (ns)	Blake (ns)	Case1 (ns)	Cains (ns)	Choi (ns)
0.1	348.6851	279.8681	280.4827	332.7211	271.6648	273.5567	353.3226
0.3	322.7192	259.2337	259.8517	297.2968	250.8466	254.6690	327.6101
0.5	298.9296	240.9524	241.5102	269.3412	232.7362	237.9119	303.9995
0.7	277.4440	224.6600	225.1420	244.7293	216.8431	222.9605	282.6120
0.9	258.0799	209.9523	210.4822	224.3422	202.7881	209.5511	263.2804
1.0	249.1383	203.2844	203.7217	214.8802	196.3543	203.3557	254.3343
2.0	181.4550	151.6684	151.9365	150.6470	147.6423	155.3578	186.1921
3.0	140.0416	118.9465	119.1194	114.3467	116.6830	123.9835	144.1303
4.0	112.9510	96.9499	97.0258	91.4029	95.3896	102.1137	116.4711
5.0	94.1605	81.2162	81.3942	75.7253	79.9267	86.1315	97.2189
6.0	80.4965	69.7667	69.8734	64.5244	68.5224	74.0212	83.1844
7.0	70.1783	61.0130	61.0914	56.2333	59.9972	64.5782	72.5669
8.0	62.1439	54.0533	54.2076	49.7251	53.3713	57.0420	64.2883
9.0	55.7287	48.6167	48.6848	44.5446	48.0750	50.9108	57.6713
10.0	50.5003	44.1820	44.1663	40.3003	43.7459	45.8414	52.2741
20.0	26.1525	22.9263	22.9627	20.8283	23.2593	21.7009	27.0961

TIME DELAY: HIRAS Data Global Winter 1800Hrs

Elev Ang (deg)	Stratified (ns)	Hopfield (ns)	Goad (ns)	Blake (ns)	Case1 (ns)	Cains (ns)	Choi (ns)
0.1	348.3403	279.8589	280.4384	331.9434	271.6648	273.1582	352.9722
0.3	322.4757	259.2295	259.8126	297.1038	250.8466	254.2980	327.3096
0.5	298.7661	240.9517	241.4753	268.9641	232.7362	237.5654	303.7436
0.7	277.3395	224.6617	225.1104	244.3483	216.8431	222.6357	282.3948
0.9	258.0190	209.9563	210.4534	223.7645	202.7881	209.2459	263.0962
1.0	249.0945	203.2889	203.6941	214.6744	196.3543	203.0594	254.1648
2.0	181.4873	151.6759	151.9168	150.4813	147.6423	155.1314	186.1165
3.0	140.0843	118.9540	119.1039	114.2407	116.6830	123.8029	144.0947
4.0	112.9914	96.9564	97.0130	91.2822	95.3896	101.9650	116.4537
5.0	94.1966	81.2227	81.3834	75.7895	79.9267	86.0060	97.2104
6.0	80.5285	69.7722	69.8640	64.5917	68.5224	73.9134	83.1805
7.0	70.2068	61.0179	61.0831	56.1644	59.9972	64.4842	72.5656
8.0	62.1694	54.0581	54.2002	49.6635	53.3713	56.9589	64.2883
9.0	55.7519	48.6208	48.6781	44.4893	48.0750	50.8366	57.6722
10.0	50.5214	44.1853	44.1602	40.2052	43.7459	45.7746	52.2755
20.0	26.1636	22.9283	22.9595	20.7981	23.2593	21.6693	27.0979

TIME DELAY: HIRAS Data Global Spring 0000Hrs

Elev Ang (deg)	Stratified (ns)	Hopfield (ns)	Goad (ns)	Blake (ns)	Case1 (ns)	Cains (ns)	Choi (ns)
0.1	349.7325	279.9247	281.5433	333.4644	271.6648	274.7200	354.2272
0.3	323.5460	259.3167	260.7987	298.5523	250.8466	255.7520	328.3719
0.5	299.5528	240.8716	242.3657	269.6415	232.7362	238.9236	304.6138
0.7	277.9101	224.5822	225.9230	245.2284	216.8431	223.9086	283.1022
0.9	258.4271	209.8807	211.2016	224.8639	202.7881	210.4422	263.6693
1.0	249.4374	203.1514	204.4141	215.4158	196.3543	204.2204	254.6799
2.0	181.5074	151.4717	152.4465	150.8816	147.6423	156.0184	186.2770
3.0	140.0251	118.7584	119.5270	114.6205	116.6830	124.5108	144.1173
4.0	112.9138	96.7762	97.3653	91.4804	95.3896	102.5479	116.4212
5.0	94.1179	81.1283	81.6844	75.7093	79.9267	86.4978	97.1561
6.0	80.4538	69.6421	70.1261	64.6229	68.5224	74.3360	83.1185
7.0	70.1374	60.9104	61.3147	56.2158	59.9972	64.8528	72.5021
8.0	62.1054	54.0663	54.4074	49.7121	53.3713	57.2845	64.2262
9.0	55.6928	48.5442	48.8654	44.4903	48.0750	51.1273	57.6125
10.0	50.4668	44.0354	44.3309	40.3217	43.7459	46.0363	52.2188
20.0	26.1334	22.8241	23.0498	20.8352	23.2593	21.7932	27.0637

TIME DELAY: HIRAS Data Global Spring 0600Hrs

Elev Ang (deg)	Stratified (ns)	Hopfield (ns)	Goad (ns)	Blake (ns)	Case1 (ns)	Cains (ns)	Choi (ns)
0.1	349.1690	279.7829	281.4504	332.8626	271.6648	274.1221	353.6681
0.3	323.1387	259.1876	260.7184	297.9797	250.8466	255.1954	327.8871
0.5	299.2688	240.7537	242.2960	269.6415	232.7362	238.4037	304.1957
0.7	277.7166	224.4735	225.8620	245.2227	216.8431	223.4214	282.7421
0.9	258.3003	209.7804	211.1479	224.0916	202.7881	209.9843	263.3591
1.0	249.3369	203.0548	204.3636	215.2014	196.3543	203.7760	254.3918
2.0	181.5269	151.4020	152.4172	150.7742	147.6423	155.6789	186.1332
3.0	140.0659	118.7047	119.5081	114.1791	116.6830	124.2398	144.0376
4.0	112.9557	96.7327	97.3519	91.4877	95.3896	102.3248	116.3723
5.0	94.1565	81.0922	81.6743	75.8060	79.9267	86.3095	97.1236
6.0	80.4887	69.6113	70.1181	64.4887	68.5224	74.1742	83.0954
7.0	70.1688	60.8834	61.3081	56.2308	59.9972	64.7117	72.4847
8.0	62.1338	54.0424	54.4018	49.7844	53.3713	57.1599	64.2125
9.0	55.7185	48.5227	48.8605	44.4780	48.0750	51.0160	57.6014
10.0	50.4904	44.0160	44.3266	40.3665	43.7459	45.9362	52.2095
20.0	26.1460	22.8143	23.0478	20.7795	23.2593	21.7458	27.0603

TIME DELAY: HIRAS Data Global Spring 1200Hrs

Elev Ang (deg)	Stratified (ns)	Hopfield (ns)	Goad (ns)	Blake (ns)	Case1 (ns)	Cains (ns)	Choi (ns)
0.1	348.9413	279.6860	281.5258	332.4778	271.6648	273.9933	353.4841
0.3	322.8806	259.0861	260.7868	298.1668	250.8466	255.0754	327.7172
0.5	298.9934	240.6487	242.3590	269.4529	232.7362	238.2916	304.0390
0.7	277.4358	224.3688	225.9208	244.8444	216.8431	223.3164	282.5972
0.9	258.0216	209.6759	211.2034	224.2762	202.7881	209.8856	263.2250
1.0	249.0612	202.9513	204.4178	215.3844	196.3543	203.6802	254.2627
2.0	181.3058	151.3119	152.4620	150.5627	147.6423	155.6057	186.0411
3.0	139.8949	118.6292	119.5469	114.4274	116.6830	124.1814	143.9675
4.0	112.8193	96.6695	97.3860	91.5428	95.3896	102.2767	116.3162
5.0	94.0442	81.0374	81.7044	75.8601	79.9267	86.2690	97.0771
6.0	80.3935	69.5636	70.1449	64.5910	68.5224	74.1394	83.0557
7.0	70.0864	60.8417	61.3322	56.1469	59.9972	64.6813	72.4502
8.0	62.0612	54.0054	54.4236	49.7028	53.3713	57.1330	64.1821
9.0	55.6537	48.4892	48.8804	44.6330	48.0750	50.9920	57.5741
10.0	50.4318	43.9854	44.3448	40.3826	43.7459	45.9146	52.1848
20.0	26.1160	22.7973	23.0576	20.8082	23.2593	21.7355	27.0475

TIME DELAY: HIRAS Data Global Spring 1800Hrs

Elev Ang (deg)	Stratified (ns)	Hopfield (ns)	Goad (ns)	Blake (ns)	Case1 (ns)	Cains (ns)	Choi (ns)
0.1	349.1422	279.7469	281.4919	333.0505	271.6648	274.1125	353.6396
0.3	323.1065	259.1486	260.7558	297.9796	250.8466	255.1864	327.8592
0.5	299.2332	240.7123	242.3302	269.2644	232.7362	238.3953	304.1686
0.7	277.6795	224.4317	225.8937	244.8456	216.8431	223.4135	282.7157
0.9	258.2628	209.7380	211.1775	224.0913	202.7881	209.9769	263.3335
1.0	249.2995	203.0127	204.3924	214.8240	196.3543	203.7688	254.3667
2.0	181.4953	151.3644	152.4402	150.6783	147.6423	155.6734	186.1122
3.0	140.0408	118.6729	119.5275	114.3649	116.6830	124.2354	144.0201
4.0	112.9353	96.7060	97.3688	91.2965	95.3896	102.3212	116.3576
5.0	94.1396	81.0689	81.6891	75.8972	79.9267	86.3065	97.1110
6.0	80.4742	69.5910	70.1312	64.5326	68.5224	74.1716	83.0844
7.0	70.1562	60.8656	61.3198	56.2281	59.9972	64.7094	72.4750
8.0	62.1226	54.0266	54.4124	49.6408	53.3713	57.1579	64.2039
9.0	55.7086	48.5084	48.8701	44.5694	48.0750	51.0142	57.5936
10.0	50.4814	44.0029	44.3354	40.3165	43.7459	45.9345	52.2024
20.0	26.1413	22.8070	23.0525	20.7780	23.2593	21.7450	27.0565

TIME DELAY: HIRAS Data Global Summer 0000Hrs

Elev Ang (deg)	Stratified (ns)	Hopfield (ns)	Goad (ns)	Blake (ns)	Case1 (ns)	Cains (ns)	Choi (ns)
0.1	354.0855	280.6805	284.2650	338.1347	271.6648	278.2040	357.9438
0.3	327.3742	259.5253	263.1954	302.2931	250.8466	258.9954	331.6736
0.5	302.9502	240.9552	244.5026	273.1509	232.7362	241.9537	307.5594
0.7	280.9463	224.5381	227.8494	247.6379	216.8431	226.7482	285.7324
0.9	261.1548	209.7305	212.9552	226.7795	202.7881	213.1110	266.0185
1.0	252.0284	202.8776	206.0929	217.1872	196.3543	206.8103	256.9012
2.0	183.1916	151.1245	153.6330	151.5324	147.6423	157.9970	187.6058
3.0	141.2575	118.3747	120.4539	114.8807	116.6830	126.0898	144.9974
4.0	113.8820	96.3938	98.1276	91.7457	95.3896	103.8484	117.0570
5.0	94.9134	80.7194	82.3312	76.0842	79.9267	87.5947	97.6463
6.0	81.1280	69.3085	70.6868	64.8359	68.5224	75.2787	83.5148
7.0	70.7218	60.6574	61.8088	56.3408	59.9972	65.6753	72.8339
8.0	62.6209	53.7881	54.8485	49.8230	53.3713	58.0110	64.5114
9.0	56.1538	48.2623	49.2635	44.6541	48.0750	51.7757	57.8625
10.0	50.8837	43.8087	44.6934	40.4574	43.7459	46.6202	52.4415
20.0	26.3479	22.7210	23.2410	20.8787	23.2593	22.0696	27.1720

TIME DELAY: HIRAS Data Global Summer 0600Hrs

Elev Ang (deg)	Stratified (ns)	Hopfield (ns)	Goad (ns)	Blake (ns)	Case1 (ns)	Cains (ns)	Choi (ns)
0.1	354.0914	280.5818	284.3061	337.9424	271.6648	278.1448	357.9533
0.3	327.4406	259.4236	263.2337	301.9153	250.8466	258.9403	331.6926
0.5	303.0592	240.8536	244.5388	272.3967	232.7362	241.9021	307.5864
0.7	281.0816	224.4386	227.8840	247.4488	216.8431	226.7000	285.7658
0.9	261.3055	209.6328	212.9888	226.7778	202.7881	213.0657	266.0570
1.0	252.1836	202.7807	206.1259	217.3732	196.3543	206.7663	256.9417
2.0	183.3402	151.0438	153.6627	151.3333	147.6423	157.9634	187.6545
3.0	141.3780	118.3077	120.4808	114.9591	116.6830	126.0630	145.0441
4.0	113.9798	96.3378	98.1518	91.7277	95.3896	103.8263	117.0991
5.0	94.9947	80.6707	82.3529	76.0656	79.9267	87.5761	97.6838
6.0	81.1972	69.2665	70.7063	64.8178	68.5224	75.2627	83.5482
7.0	70.7819	60.6209	61.8264	56.3703	59.9972	65.6613	72.8638
8.0	62.6740	53.7553	54.8646	49.8536	53.3713	57.9987	64.5383
9.0	56.2013	48.2325	49.2781	44.5922	48.0750	51.7646	57.8871
10.0	50.9266	43.7818	44.7069	40.4433	43.7459	46.6102	52.4639
20.0	26.3699	22.7065	23.2484	20.8481	23.2593	22.0649	27.1840

TIME DELAY: HIRAS Data Global Summer 1200Hrs

Elev Ang (deg)	Stratified (ns)	Hopfield (ns)	Goad (ns)	Blake (ns)	Case1 (ns)	Cains (ns)	Choi (ns)
0.1	353.3971	280.5158	284.2738	337.3400	271.6648	277.5813	357.3263
0.3	326.7857	259.3625	263.2060	301.5309	250.8466	258.4158	331.1333
0.5	302.4470	240.7968	244.5150	272.0197	232.7362	241.4122	307.0886
0.7	280.5131	224.3857	227.8636	247.0668	216.8431	226.2408	285.3220
0.9	260.7794	209.5833	212.9711	226.1955	202.7881	212.6341	265.6605
1.0	251.6779	202.7329	206.1094	217.1607	196.3543	206.3475	256.5665
2.0	182.9947	151.0080	153.6543	151.3264	147.6423	157.6434	187.4253
3.0	141.1268	118.2797	120.4761	114.7151	116.6830	125.8076	144.8880
4.0	113.7856	96.3149	98.1491	91.7451	95.3896	103.6160	116.9834
5.0	94.8374	80.6516	82.3512	75.9848	79.9267	87.3987	97.5927
6.0	81.0653	69.2501	70.7052	64.7879	68.5224	75.1103	83.4734
7.0	70.6685	60.6066	61.8257	56.4420	59.9972	65.5283	72.8005
8.0	62.5746	53.7426	54.8640	49.7940	53.3713	57.8812	64.4834
9.0	56.1127	48.2211	49.2777	44.5891	48.0750	51.6598	57.8386
10.0	50.8469	43.7714	44.7066	40.4023	43.7459	46.5158	52.4205
20.0	26.3294	22.7011	23.2483	20.8866	23.2593	22.0202	27.1624

TIME DELAY: HIRAS Data Global Summer 1800Hrs

Elev Ang (deg)	Stratified (ns)	Hopfield (ns)	Goad (ns)	Blake (ns)	Case1 (ns)	Cains (ns)	Choi (ns)
0.1	353.9498	280.5343	284.2701	338.1228	271.6648	278.0214	357.8237
0.3	327.3116	259.3811	263.2025	301.7252	250.8466	258.8255	331.5780
0.5	302.9423	240.8151	244.5115	272.5853	232.7362	241.7949	307.4855
0.7	280.9759	224.4033	227.8601	247.6363	216.8431	226.5995	285.6768
0.9	261.2098	209.6005	212.9675	226.5856	202.7881	212.9712	265.9784
1.0	252.0926	202.7498	206.1059	217.1794	196.3543	206.6746	256.8678
2.0	183.2818	151.0219	153.6506	151.8766	147.6423	157.8933	187.6118
3.0	141.3364	118.2911	120.4726	115.0203	116.6830	126.0071	145.0164
4.0	113.9479	96.3244	98.1458	91.8786	95.3896	103.7803	117.0793
5.0	94.9689	80.6598	82.3482	76.1218	79.9267	87.5373	97.6686
6.0	81.1756	69.2572	70.7025	64.7807	68.5224	75.2293	83.5360
7.0	70.7633	60.6127	61.8232	56.4292	59.9972	65.6322	72.8537
8.0	62.6577	53.7481	54.8618	49.9139	53.3713	57.9730	64.5296
9.0	56.1868	48.2261	49.2757	44.7012	48.0750	51.7417	57.8795
10.0	50.9136	43.7759	44.7047	40.4137	43.7459	46.5896	52.4572
20.0	26.3633	22.7035	23.2473	20.8768	23.2593	22.0551	27.1807

TIME DELAY: HIRAS Data Global Fall 0000Hrs

Elev Ang (deg)	Stratified (ns)	Hopfield (ns)	Goad (ns)	Blake (ns)	Case1 (ns)	Cains (ns)	Choi (ns)
0.1	350.3767	279.9967	281.8127	334.4427	271.6648	275.1566	354.8984
0.3	324.0715	259.2805	261.0320	298.9464	250.8466	256.1584	328.9986
0.5	299.9994	240.8782	242.5708	270.0313	232.7362	239.3034	305.2106
0.7	278.2988	224.4190	226.1055	245.6216	216.8431	224.2645	283.6690
0.9	258.7704	209.8255	211.3658	224.6990	202.7881	210.7767	264.2052
1.0	249.7617	203.0878	204.5706	215.4442	196.3543	204.5450	255.2004
2.0	181.7220	151.4237	152.5538	151.0742	147.6423	156.2664	186.6667
3.0	140.1896	118.6964	119.6101	114.6831	116.6830	124.7086	144.4196
4.0	113.0468	96.7147	97.4335	91.4760	95.3896	102.7109	116.6646
5.0	94.2288	81.0566	81.7423	75.9280	79.9267	86.6353	97.3585
6.0	80.5485	69.6290	70.1763	64.6031	68.5224	74.4542	83.2911
7.0	70.2198	60.8659	61.3590	56.2290	59.9972	64.9559	72.6522
8.0	62.1782	53.9474	54.4470	49.7232	53.3713	57.3756	64.3589
9.0	55.7579	48.4992	48.9011	44.5316	48.0750	51.2085	57.7314
10.0	50.5258	44.0017	44.3635	40.3583	43.7459	46.1095	52.3263
20.0	26.1636	22.8431	23.0670	20.8403	23.2593	21.8278	27.1191

TIME DELAY: HIRAS Data Global Fall 0600Hrs

Elev Ang (deg)	Stratified (ns)	Hopfield (ns)	Goad (ns)	Blake (ns)	Case1 (ns)	Cains (ns)	Choi (ns)
0.1	350.1113	279.8488	281.7452	333.6695	271.6648	274.8455	354.6391
0.3	323.9035	259.1429	260.9744	298.7542	250.8466	255.8688	328.7788
0.5	299.9064	240.7500	242.5214	270.0313	232.7362	239.0328	305.0263
0.7	278.2591	224.2991	226.0631	245.4301	216.8431	224.0109	283.5152
0.9	258.7684	209.7132	211.3293	224.5011	202.7881	210.5383	264.0773
1.0	249.7740	202.9790	204.5367	215.4307	196.3543	204.3137	255.0839
2.0	181.7891	151.3420	152.5370	150.8299	147.6423	156.0897	186.6224
3.0	140.2557	118.6321	119.6013	114.5063	116.6830	124.5676	144.4045
4.0	113.1045	96.6623	97.4287	91.5704	95.3896	102.5948	116.6620
5.0	94.2784	81.0125	81.7396	75.8315	79.9267	86.5373	97.3613
6.0	80.5916	69.5912	70.1748	64.7435	68.5224	74.3700	83.2963
7.0	70.2577	60.8328	61.3582	56.1391	59.9972	64.8825	72.6585
8.0	62.2119	53.9180	54.4466	49.7329	53.3713	57.3107	64.3655
9.0	55.7883	48.4728	48.9010	44.4525	48.0750	51.1506	57.7380
10.0	50.5533	43.9778	44.3635	40.3778	43.7459	46.0574	52.3329
20.0	26.1780	22.8307	23.0673	20.8200	23.2593	21.8031	27.1233

TIME DELAY: HIRAS Data Global Fall 1200Hrs

Elev Ang (deg)	Stratified (ns)	Hopfield (ns)	Goad (ns)	Blake (ns)	Case1 (ns)	Cains (ns)	Choi (ns)
0.1	349.6877	279.7878	281.7598	333.4596	271.6648	274.4946	354.2623
0.3	323.5055	259.0819	260.9883	298.5616	250.8466	255.5422	328.4442
0.5	299.5354	240.6896	242.5349	269.8428	232.7362	238.7276	304.7299
0.7	277.9156	224.2398	226.0764	245.2383	216.8431	223.7250	283.2523
0.9	258.4514	209.6557	211.3425	224.6790	202.7881	210.2696	263.8436
1.0	249.4696	202.9226	204.5499	215.6041	196.3543	204.0529	254.8634
2.0	181.5827	151.2953	152.5500	151.0497	147.6423	155.8904	186.4912
3.0	140.1063	118.5937	119.6136	114.4133	116.6830	124.4086	144.3171
4.0	112.9892	96.6303	97.4400	91.4644	95.3896	102.4638	116.5984
5.0	94.1851	80.9850	81.7499	75.7231	79.9267	86.4268	97.3120
6.0	80.5134	69.5675	70.1841	64.6848	68.5224	74.2750	83.2562
7.0	70.1905	60.8119	61.3667	56.2731	59.9972	64.7996	72.6248
8.0	62.1530	53.8992	54.4543	49.7780	53.3713	57.2376	64.3364
9.0	55.7358	48.4561	48.9081	44.5506	48.0750	51.0853	57.7124
10.0	50.5060	43.9626	44.3700	40.4346	43.7459	45.9986	52.3100
20.0	26.1540	22.8226	23.0709	20.8440	23.2593	21.7753	27.1121

TIME DELAY: HIRAS Data Global Fall 1800Hrs

Elev Ang (deg)	Stratified (ns)	Hopfield (ns)	Goad (ns)	Blake (ns)	Case1 (ns)	Cains (ns)	Choi (ns)
0.1	349.9996	279.8253	281.7437	334.0397	271.6648	274.7332	354.5510
0.3	323.8067	259.1201	260.9735	298.5644	250.8466	255.7643	328.7052
0.5	299.8229	240.7279	242.5210	269.8428	232.7362	238.9351	304.9655
0.7	278.1870	224.2779	226.0631	245.4291	216.8431	223.9194	283.4654
0.9	258.7060	209.6929	211.3297	224.6862	202.7881	210.4524	264.0369
1.0	249.7159	202.9592	204.5373	215.4259	196.3543	204.2302	255.0477
2.0	181.7577	151.3262	152.5387	151.0925	147.6423	156.0259	186.6117
3.0	140.2357	118.6193	119.6034	114.3823	116.6830	124.5168	144.4036
4.0	113.0901	96.6517	97.4309	91.5365	95.3896	102.5529	116.6649
5.0	94.2673	81.0035	81.7417	75.8910	79.9267	86.5019	97.3657
6.0	80.5826	69.5834	70.1768	64.6158	68.5224	74.3396	83.3012
7.0	70.2500	60.8259	61.3600	56.2475	59.9972	64.8560	72.6634
8.0	62.2053	53.9118	54.4483	49.7487	53.3713	57.2873	64.3703
9.0	55.7824	48.4673	48.9025	44.5178	48.0750	51.1297	57.7425
10.0	50.5481	43.9728	44.3649	40.3510	43.7459	46.0386	52.3371
20.0	26.1754	22.8280	23.0681	20.8294	23.2593	21.7942	27.1259

Appendix F

TIME DELAYS AND ANGLE ERRORS OF 42 AREAS OF INTEREST FOR SEASONS/ANGLES BY HOURS

Time delays of 42 areas of interest are compared for each model by seasons and elevation angles from the horizon to 10° above the horizon.

Time Delay (ns)
February
using ECM Data and Hopfield, Goad and Exponential Models
(Models use ECM Surface Data)

AOI	Elevation Angle = 0.0°				Elevation Angle = 1.0°				Elevation Angle = 3.0°				Elevation Angle = 5.0°				Elevation Angle = 10.0°			
	ECM	Hopfld	Goad	Exp	ECM	Hopfld	Goad	Exp	ECM	Hopfld	Goad	Exp	ECM	Hopfld	Goad	Exp	ECM	Hopfld	Goad	Exp
Ahaggar, Algeria	327.2	272.8	280.5	331.3	232.1	191.2	198.4	235.8	134.4	112.0	117.5	137.7	91.2	76.6	80.8	94.0	49.2	41.6	44.0	51.0
Bering Sea	338.3	293.1	288.5	344.7	235.6	205.4	201.3	242.1	133.3	120.4	117.5	138.7	89.8	82.3	80.2	93.9	48.2	44.7	43.5	50.7
Albuquerque, New Mexico	346.8	288.6	292.7	352.8	241.5	200.9	204.9	247.9	137.4	117.2	120.3	142.5	92.8	80.0	82.4	96.7	49.9	43.4	44.8	52.2
Alberta, Canada	346.5	296.9	293.4	352.8	240.9	207.9	204.8	247.1	136.5	121.8	119.7	141.7	92.0	83.3	81.7	96.0	49.4	45.2	44.3	51.8
Alp Mountains	354.0	298.2	297.5	360.3	244.6	207.7	207.2	251.6	138.0	121.2	121.0	143.6	92.9	82.8	82.7	97.2	49.9	44.9	44.9	52.4
Amazon Forest	424.1	323.8	330.7	420.9	284.7	218.9	225.8	283.2	156.1	125.0	130.5	154.5	104.2	84.8	89.0	102.8	55.6	45.7	48.2	54.7
Aguas, Mexico	367.4	295.6	302.5	369.3	255.0	203.8	210.5	256.5	144.1	118.0	123.2	145.4	97.1	80.4	84.4	98.1	52.1	43.5	45.9	52.7
GIUK (Grnland, Iceland, UK)	346.0	294.8	292.4	352.4	239.6	205.8	203.8	246.6	135.3	120.3	119.0	140.9	91.1	82.2	81.2	95.4	48.9	44.6	44.1	51.4
Baghdad, Iraq	347.4	290.4	293.2	353.1	241.7	202.3	205.1	247.8	137.4	118.1	120.3	142.3	92.7	80.6	82.3	96.5	49.8	43.7	44.7	52.1
Bangkok, Thailand	420.2	322.2	329.4	416.3	279.7	217.9	225.1	279.7	152.9	124.5	130.1	152.3	102.1	84.4	88.7	101.2	54.5	45.5	48.1	53.8
Cape Town, South Africa	381.5	306.9	311.1	383.5	257.0	210.6	214.9	263.2	142.8	121.6	125.1	147.1	95.8	82.8	85.4	98.7	51.4	44.8	46.4	52.9
Washington, D.C.	349.2	295.8	294.5	354.9	241.7	206.6	205.6	248.5	137.0	120.8	120.2	142.3	92.4	82.6	82.1	96.4	49.6	44.8	44.6	52.0
East Congo (Zaire)	429.1	324.7	333.1	424.9	288.4	219.0	227.3	285.4	158.0	124.8	131.2	155.3	105.4	84.6	89.5	103.2	56.3	45.6	48.5	54.9
Greenland	334.6	295.3	286.4	339.9	233.5	208.2	200.1	238.6	132.5	122.6	116.6	136.9	89.2	83.9	79.5	92.8	47.9	45.6	43.1	50.0
Hawaii Area	402.2	315.9	322.0	400.2	267.5	215.0	221.1	270.7	146.9	123.3	128.2	148.7	98.3	83.8	87.5	99.2	52.6	45.2	47.5	52.9
Huancayo, Peru	420.9	322.1	328.5	418.6	286.1	218.4	224.8	283.6	158.2	125.0	130.1	156.1	105.7	84.9	88.7	104.1	56.5	45.8	48.1	55.5
Indian Ocean (Diego Garcia)	426.3	324.7	331.3	423.3	285.9	219.5	226.1	285.2	156.7	125.3	130.5	155.8	104.6	85.0	89.0	103.6	55.8	45.8	48.2	55.2
Irkutsk, Siberia	346.3	304.2	295.3	352.9	240.9	214.3	206.2	247.0	136.3	126.1	120.2	141.5	91.8	86.3	81.9	95.9	49.2	46.9	44.4	51.8
Korea & Japan (Lower Sea of Japan)	347.0	296.8	294.3	352.6	240.2	207.6	205.5	246.6	135.9	121.6	120.1	141.1	91.6	83.1	82.0	95.5	49.2	45.1	44.5	51.5
Kabul, Afghanistan	353.5	293.8	296.4	358.5	245.3	204.2	206.9	250.7	139.0	119.0	121.2	143.4	93.7	81.2	82.9	97.1	50.3	44.0	45.0	52.3
Kashmir, India	361.1	297.6	300.3	366.1	249.0	206.2	209.0	254.9	140.3	119.8	122.1	145.0	94.5	81.7	83.5	98.0	50.7	44.3	45.4	52.7
LaPaz, Bolivia	396.3	310.7	317.0	394.8	270.8	212.1	218.4	269.7	150.9	122.0	126.9	149.8	101.2	83.0	86.7	100.3	54.2	44.8	47.1	53.6
Lhasa, Tibet (Himalayas)	348.9	289.6	293.2	353.5	243.4	201.6	205.2	248.2	138.6	117.6	120.4	142.6	93.6	80.3	82.4	96.7	50.3	43.5	44.8	52.2
Manaus, Brazil (Amazon Forest)	430.3	326.5	333.0	426.9	288.2	220.4	227.0	287.2	157.7	125.7	131.0	156.6	105.2	85.3	89.3	104.1	56.2	46.0	48.4	55.4
Manila, Philippines	415.6	319.7	327.0	412.1	276.6	216.6	223.9	278.1	151.7	123.9	129.6	152.3	101.4	84.1	88.4	101.4	54.2	45.4	48.0	54.0
Miami, Florida	389.4	311.3	315.6	390.0	261.2	213.2	217.6	266.4	144.6	122.9	126.4	148.1	96.9	83.6	86.3	99.2	51.9	45.2	46.8	53.0
Northwest Africa: Morocco	364.7	299.9	303.4	369.9	250.5	207.4	210.9	257.0	140.8	120.4	123.2	145.9	94.8	82.1	84.2	98.5	50.9	44.4	45.7	53.0
Moscow, Russia	345.4	302.9	293.3	351.9	239.4	213.3	204.5	246.3	135.4	125.5	119.0	141.1	91.2	85.9	81.1	95.6	48.9	46.6	43.9	51.6
Alaska	338.6	293.1	288.6	345.1	235.8	205.3	201.4	242.4	133.4	120.3	117.5	138.9	89.8	82.3	80.2	94.1	48.2	44.6	43.5	50.7
Northern Australia: Tanami Desert	379.8	298.2	308.1	379.0	263.0	204.0	213.5	261.8	148.1	117.5	124.8	147.2	99.6	79.9	85.4	99.0	53.5	43.2	46.5	53.1
New Guinea	438.5	329.8	338.9	435.1	293.9	222.2	229.3	291.9	160.6	126.5	132.2	158.7	107.0	85.8	90.1	105.4	57.1	46.2	48.8	56.0
Prince Edward Island, Canada	343.2	298.9	291.4	349.1	237.9	210.2	203.2	244.3	134.7	123.5	118.4	139.9	90.8	84.5	80.8	94.8	48.7	45.9	43.7	51.1
Portland, Oregon	358.5	300.3	299.6	364.4	246.0	208.7	208.3	253.8	138.4	121.6	121.5	144.4	93.1	83.0	83.0	97.6	50.0	45.0	45.0	52.5
Pyrenee Mountains	358.3	299.6	299.8	364.4	247.0	208.3	208.6	254.0	139.1	121.3	121.8	144.7	93.6	82.8	83.2	97.8	50.2	44.9	45.2	52.7
Quito, Ecuador	424.9	324.4	331.2	421.1	285.4	219.5	226.3	283.1	156.6	125.4	130.7	154.4	104.5	85.1	89.1	102.7	55.8	45.9	48.3	54.6
Santiago, Chile	369.2	299.2	304.6	372.3	251.2	206.1	211.3	257.4	140.7	119.3	123.4	145.2	94.7	81.3	84.4	97.7	50.8	44.0	45.9	52.5
Spokane, Washington	351.6	297.7	296.0	357.9	243.5	207.8	206.4	250.3	137.7	121.4	120.6	143.2	92.8	83.0	82.3	97.0	49.8	45.0	44.7	52.3
Tangmai, Tibet	372.7	302.2	306.0	373.8	256.5	208.3	212.1	257.9	144.1	120.7	123.7	145.1	96.8	82.2	84.6	97.6	51.9	44.5	45.9	52.4
Tehran, Iran	359.5	297.7	299.8	364.2	248.7	206.5	208.7	253.5	140.3	120.2	122.0	144.1	94.4	82.0	83.4	97.4	50.7	44.4	45.3	52.4
Tucson, Arizona	349.3	288.7	294.1	355.6	241.9	200.4	205.7	249.6	137.3	116.7	120.8	143.3	92.7	79.6	82.7	97.1	49.8	43.1	45.0	52.4
Ural Mountains	346.8	306.7	294.3	353.3	239.7	216.4	204.9	247.0	135.3	127.4	119.0	141.2	91.1	87.2	81.0	95.6	48.9	47.4	43.8	51.5
Xining, China	351.1	293.8	295.1	356.7	244.0	204.7	206.0	250.0	138.4	119.5	120.6	143.4	93.3	81.6	82.5	97.2	50.1	44.2	44.8	52.4

Time Delay (ns)
May
using ECM Data and Hopfield, Goad and Exponential Models
(Models use ECM Surface Data)

AOI	Elevation Angle = 0.0°				Elevation Angle = 1.0°				Elevation Angle = 3.0°				Elevation Angle = 5.0°				Elevation Angle = 10.0°			
	ECM	Hopfld	Goad	Exp	ECM	Hopfld	Goad	Exp	ECM	Hopfld	Goad	Exp	ECM	Hopfld	Goad	Exp	ECM	Hopfld	Goad	Exp
Ahaggar, Algeria	336.8	272.4	284.7	340.5	237.9	189.2	200.9	241.9	137.3	110.2	119.0	140.8	93.1	75.2	81.9	96.0	50.2	40.7	44.7	52.0
Bering Sea	349.3	296.9	293.8	355.1	242.0	207.5	204.7	248.3	136.9	121.3	119.4	142.0	92.2	82.9	81.5	96.1	49.5	45.0	44.2	51.8
Albuquerque, New Mexico	349.0	284.0	292.5	353.8	243.6	196.8	204.9	248.9	139.0	114.4	120.6	143.3	93.9	78.0	82.7	97.2	50.5	42.3	45.0	52.5
Alberta, Canada	363.6	299.7	301.5	368.7	250.4	207.5	209.5	256.2	140.8	120.6	122.2	145.4	94.7	82.2	83.5	98.2	50.8	44.5	45.3	52.8
Alp Mountains	373.6	303.4	306.8	377.7	255.6	209.0	212.5	260.9	143.0	121.0	123.8	147.1	96.0	82.4	84.6	99.0	51.5	44.6	45.9	53.2
Amazon Forest	427.6	325.5	332.4	424.0	286.2	219.9	226.9	284.6	156.6	125.5	131.0	154.9	104.5	85.1	89.3	102.9	55.8	45.9	48.4	54.8
Aguas, Mexico	371.7	295.5	304.1	373.1	257.8	203.1	211.4	258.9	145.7	117.3	123.7	146.6	98.1	79.9	84.7	98.8	52.7	43.2	46.1	53.1
GIUK (Grnland, Iceland, UK)	355.9	299.0	297.6	361.8	245.5	208.1	207.1	252.2	138.4	121.4	120.8	143.8	93.2	82.9	82.5	97.2	50.0	44.9	44.8	52.4
Baghdad, Iraq	355.7	285.9	295.6	359.9	248.2	197.3	206.6	252.6	141.3	114.4	121.4	144.9	95.3	78.0	83.3	98.2	51.3	42.2	45.3	53.0
Bangkok, Thailand	432.5	326.4	334.4	429.1	288.4	219.9	227.9	288.4	157.4	125.2	131.4	157.0	104.9	84.9	89.6	104.3	56.0	45.7	48.6	55.5
Cape Town, South Africa	378.0	306.8	309.8	380.7	254.5	211.1	214.2	262.0	141.6	122.1	124.6	147.0	95.1	83.2	85.1	98.8	51.0	45.0	46.2	53.0
Washington, D.C.	378.6	304.5	309.4	381.1	258.1	209.2	214.1	262.4	144.1	120.9	124.8	147.3	96.8	82.3	85.3	99.0	51.9	44.5	46.3	53.1
East Congo (Zaire)	432.0	326.2	334.4	428.1	289.2	219.9	228.0	286.7	158.0	125.3	131.6	155.6	105.3	84.9	89.7	103.3	56.2	45.8	48.7	54.9
Greenland	345.9	296.1	292.6	351.6	240.3	207.4	204.3	246.2	136.2	121.5	119.3	141.1	91.8	83.1	81.5	95.7	49.3	45.1	44.2	51.6
Hawaii Area	407.5	318.1	324.3	403.9	270.6	218.2	222.4	272.3	148.4	124.0	128.9	149.1	99.3	84.2	87.9	99.3	53.1	45.5	47.7	52.9
Huancayo, Peru	423.6	324.6	330.5	419.4	285.9	220.1	226.0	282.3	157.4	125.9	130.6	154.3	105.1	85.5	89.1	102.7	56.2	46.1	48.3	54.7
Indian Ocean (Diego Garcia)	424.9	324.2	330.8	421.5	284.8	219.2	225.9	283.7	156.1	125.2	130.4	154.8	104.2	84.9	88.9	103.0	55.7	45.8	48.2	54.8
Irkutsk, Siberia	361.1	298.4	300.3	366.7	249.1	206.8	208.8	255.4	140.4	120.3	121.9	145.3	94.4	82.0	83.3	98.2	50.7	44.4	45.2	52.9
Korea & Japan (Lower Sea of Japan)	373.2	303.0	306.0	375.7	254.1	208.8	211.9	259.3	142.1	120.9	123.4	145.9	95.5	82.4	84.3	98.2	51.3	44.6	45.8	52.7
Kabul, Afghanistan	351.4	285.2	293.5	355.9	245.3	197.4	205.4	250.1	139.8	114.7	120.8	143.7	94.5	78.2	82.8	97.4	50.8	42.3	45.1	52.6
Kashmir, India	374.9	298.0	306.1	376.4	258.2	204.4	212.2	260.4	145.1	118.0	124.0	146.7	97.6	80.3	84.9	98.7	52.4	43.4	46.1	53.0
LaPaz, Bolivia	383.3	304.9	311.2	383.2	262.6	209.1	215.3	263.1	147.0	120.6	125.5	147.2	98.7	82.1	85.8	98.8	52.9	44.4	46.6	52.9
Lhasa, Tibet (Himalayas)	377.3	301.9	307.4	378.7	259.6	207.7	213.1	262.0	146.1	120.1	124.3	147.8	98.3	81.8	85.0	99.6	52.7	44.2	46.2	53.5
Manaus, Brazil (Amazon Forest)	428.5	325.4	332.5	425.3	288.1	219.7	226.9	285.9	157.9	125.3	131.0	155.8	105.4	85.0	89.3	103.6	56.3	45.8	48.4	55.1
Manila, Philippines	424.7	322.9	331.1	421.9	283.8	218.0	226.1	284.1	155.3	124.4	130.6	155.1	103.7	84.3	89.1	103.1	55.4	45.5	48.3	54.9
Miami, Florida	404.4	316.1	322.7	403.2	269.9	215.0	221.6	273.0	148.3	123.3	128.5	150.2	99.2	83.8	87.7	100.2	53.1	45.2	47.6	53.4
Northwest Africa: Morocco	371.7	301.2	307.5	375.3	254.7	206.9	213.2	259.8	142.9	119.6	124.4	146.7	96.1	81.4	85.1	98.8	51.5	44.0	46.2	53.1
Moscow, Russia	358.8	296.8	299.2	365.0	247.6	205.8	208.3	254.8	139.7	119.7	121.8	145.4	94.1	81.7	83.3	98.4	50.5	44.2	45.2	53.0
Alaska	349.7	297.0	294.0	355.5	242.1	207.4	204.8	248.5	136.9	121.3	119.5	142.0	92.2	82.9	81.6	96.1	49.5	44.9	44.2	51.8
Northern Australia: Tanami Desert	355.3	290.2	296.4	359.0	247.8	201.1	207.1	251.2	140.9	117.0	121.6	143.7	95.1	79.8	83.3	97.3	51.2	43.2	45.3	52.4
New Guinea	448.9	334.9	341.9	443.2	297.7	225.0	232.2	294.8	161.5	127.9	133.5	158.8	107.5	86.6	90.9	105.2	57.3	46.7	49.3	55.8
Prince Edward Island, Canada	357.2	298.2	297.9	362.4	246.6	207.4	207.3	252.8	139.3	120.9	121.0	144.1	93.8	82.5	82.7	97.4	50.4	44.7	44.9	52.5
Portland, Oregon	362.7	301.0	302.0	367.8	248.5	208.7	209.8	255.5	139.7	121.3	122.4	145.0	94.0	82.8	83.6	97.9	50.4	44.8	45.4	52.7
Pyrenee Mountains	371.1	301.7	305.5	375.7	254.7	208.0	211.8	260.1	142.7	120.5	123.6	146.9	95.9	82.1	84.5	99.0	51.4	44.4	45.9	53.2
Quito, Ecuador	435.8	330.0	338.1	431.6	291.3	222.7	229.0	288.9	159.1	127.0	132.0	156.8	106.1	86.1	89.9	104.1	56.6	46.4	48.7	55.4
Santiago, Chile	361.1	297.3	300.6	366.4	247.9	205.9	209.2	255.2	139.7	119.6	122.3	145.3	94.1	81.6	83.6	98.2	50.5	44.2	45.4	52.8
Spokane, Washington	363.7	299.0	301.8	368.8	250.0	206.9	209.7	256.3	140.6	120.1	122.5	145.4	94.6	81.9	83.7	98.2	50.7	44.4	45.5	52.8
Tangmai, Tibet	415.8	320.3	326.2	412.2	281.4	217.4	223.3	278.3	155.2	124.4	129.2	152.6	103.8	84.5	88.1	101.7	55.5	45.6	47.8	54.2
Tehran, Iran	371.3	297.3	304.5	373.5	255.9	204.5	211.6	259.0	144.2	118.3	123.7	146.6	97.0	80.6	84.7	98.8	52.1	43.6	46.0	53.1
Tucson, Arizona	362.2	292.8	300.6	367.2	248.6	201.7	209.2	255.7	140.1	116.8	122.6	145.3	94.4	79.6	83.9	98.1	50.7	43.1	45.7	52.8
Ural Mountains	351.8	295.7	295.4	357.9	243.6	206.0	205.9	250.4	137.8	120.3	120.4	143.4	92.9	82.1	82.3	97.1	49.9	44.5	44.6	52.4
Xining, China	391.0	309.0	314.1	390.3	267.3	211.5	216.7	267.5	149.2	121.9	126.0	149.3	100.1	82.9	86.0	100.1	53.6	44.8	46.7	53.6

Time Delay (ns)
August
using ECM Data and Hopfield, Goad and Exponential Models
(Models use ECM Surface Data)

AOI	Elevation Angle = 0.0°				Elevation Angle = 1.0°				Elevation Angle = 3.0°				Elevation Angle = 5.0°				Elevation Angle = 10.0°			
	ECM	Hopfld	Goad	Exp	ECM	Hopfld	Goad	Exp	ECM	Hopfld	Goad	Exp	ECM	Hopfld	Goad	Exp	ECM	Hopfld	Goad	Exp
Ahaggar, Algeria	352.5	280.5	294.2	355.7	246.6	193.3	206.3	250.1	140.9	111.9	121.8	143.8	95.3	76.3	83.7	97.5	51.3	41.3	45.6	52.6
Bering Sea	364.8	301.0	300.9	368.7	252.5	208.7	208.9	256.3	142.5	121.4	121.8	145.5	95.9	82.8	83.2	98.2	51.5	44.9	45.1	52.8
Albuquerque, New Mexico	401.7	308.6	319.5	399.5	274.8	209.6	220.2	273.0	153.2	120.1	128.2	151.8	102.8	81.6	87.7	101.6	55.0	44.0	47.7	54.4
Alberta, Canada	376.6	302.2	307.6	379.4	258.9	207.7	213.1	262.0	145.2	120.1	124.3	147.6	97.6	81.8	85.0	99.4	52.3	44.2	46.2	53.4
Alp Mountains	390.1	308.2	315.0	391.5	265.2	210.7	217.4	268.2	147.5	121.3	126.5	149.7	98.9	82.5	86.5	100.4	53.0	44.6	47.0	53.8
Amazon Forest	416.6	320.3	327.7	413.5	280.1	217.0	224.3	278.8	154.0	124.1	129.8	152.6	102.9	84.2	88.6	101.6	55.0	45.4	48.1	54.1
Aguas, Mexico	421.9	320.8	329.1	419.2	286.8	217.2	225.3	283.5	158.4	124.1	130.4	155.7	105.9	84.2	89.0	103.8	56.6	45.4	48.3	55.4
GIUK (Grnland, Iceland, UK)	367.5	302.3	302.9	371.7	252.4	209.2	210.0	257.6	141.8	121.5	122.4	145.8	95.4	82.9	83.6	98.3	51.2	44.9	45.3	52.9
Baghdad, Iraq	347.0	276.7	290.5	348.8	245.0	190.7	203.8	246.3	140.5	110.5	120.4	141.7	95.0	75.3	82.7	96.1	51.2	40.7	45.1	51.9
Bangkok, Thailand	426.6	323.6	331.2	423.8	285.4	218.5	226.1	286.1	156.4	124.6	130.6	156.5	104.4	84.5	89.0	104.1	55.7	45.6	48.3	55.5
Cape Town, South Africa	372.7	305.6	307.8	377.2	252.0	210.8	213.1	260.6	140.6	122.2	124.1	146.9	94.4	83.2	84.8	98.9	50.7	45.1	46.0	53.1
Washington, D.C.	415.5	320.2	327.3	412.6	278.2	217.1	224.2	278.3	152.8	124.3	129.8	152.4	102.1	84.4	88.6	101.5	54.6	45.5	48.1	54.1
East Congo (Zaire)	413.8	317.3	326.3	410.4	279.8	214.8	223.7	277.7	154.5	122.8	129.6	152.6	103.3	83.3	88.5	101.7	55.2	45.0	48.0	54.2
Greenland	351.2	294.9	294.5	356.7	243.7	205.5	205.3	249.6	138.0	120.0	120.0	142.8	93.0	81.9	82.0	96.7	50.0	44.4	44.5	52.2
Hawaii Area	416.1	321.3	328.2	411.3	275.5	217.7	224.6	275.7	150.5	124.5	130.0	150.0	100.5	84.5	88.7	99.7	53.7	45.6	48.1	53.0
Huancayo, Peru	408.2	316.6	323.2	405.8	277.4	215.4	222.1	275.6	153.8	123.6	128.8	152.2	103.0	84.0	88.0	101.7	55.1	45.3	47.7	54.3
Indian Ocean (Diego Garcia)	414.6	319.2	326.2	412.4	279.4	216.4	223.5	278.8	153.9	123.8	129.4	152.9	102.8	84.1	88.3	101.9	55.0	45.4	47.9	54.3
Irkutsk, Siberia	383.0	305.4	310.7	384.8	262.2	209.4	214.7	264.6	146.4	120.8	125.0	148.2	98.3	82.2	85.4	99.6	52.7	44.4	46.4	53.4
Korea & Japan (Lower Sea of Japan)	420.9	322.1	329.1	417.1	281.1	217.8	224.8	280.6	153.9	124.4	129.9	153.0	102.8	84.4	88.6	101.7	54.9	45.5	48.0	54.1
Kabul, Afghanistan	348.3	280.3	290.8	349.7	244.9	193.8	203.7	246.3	140.2	112.5	120.0	141.4	94.9	76.7	82.4	95.9	51.1	41.5	44.9	51.7
Kashmir, India	428.4	323.5	332.0	422.7	289.9	218.1	226.4	284.2	159.3	124.2	130.7	154.4	106.3	84.2	89.2	102.5	56.8	45.4	48.4	54.5
LaPaz, Bolivia	378.5	302.3	308.8	379.2	260.4	207.7	214.0	261.2	146.2	120.0	124.9	146.7	98.3	81.7	85.4	98.6	52.7	44.2	46.4	52.9
Lhasa, Tibet (Himalayas)	402.9	311.8	317.8	402.5	277.5	212.7	218.7	276.9	155.5	122.3	127.0	155.1	104.4	83.1	86.7	104.2	55.9	44.9	47.1	55.8
Manaus, Brazil (Amazon Forest)	418.0	320.2	328.1	415.6	282.2	216.7	224.5	280.1	155.1	123.9	129.9	153.1	103.6	84.0	88.6	101.9	55.4	45.3	48.1	54.3
Manila, Philippines	425.8	323.4	331.0	423.5	286.0	218.4	225.9	285.9	156.8	124.6	130.5	156.4	104.7	84.5	89.0	104.1	55.9	45.6	48.3	55.4
Miami, Florida	437.8	329.4	337.2	429.5	285.8	222.0	229.7	286.6	154.9	126.4	132.5	155.0	103.3	85.7	90.3	102.8	55.1	46.2	49.0	54.6
Northwest Africa: Morocco	390.4	307.7	318.1	391.2	265.9	209.4	219.4	268.8	148.4	120.1	127.8	150.4	99.7	81.6	87.4	101.0	53.4	44.1	47.5	54.1
Moscow, Russia	371.5	300.9	305.0	375.8	255.5	207.3	211.4	260.4	143.4	120.1	123.3	147.2	96.4	81.8	84.3	99.2	51.7	44.3	45.8	53.3
Alaska	365.2	301.2	301.2	369.1	252.6	208.9	209.1	256.5	142.5	121.5	121.9	145.6	95.9	82.9	83.2	98.2	51.5	44.9	45.2	52.9
Northern Australia: Tanami Desert	345.4	285.4	291.3	348.9	242.0	198.6	204.3	245.3	138.4	115.9	120.2	141.2	93.6	79.1	82.4	95.8	50.4	42.9	44.8	51.7
New Guinea	440.5	331.0	338.1	435.8	293.2	222.9	230.1	291.2	159.7	126.9	132.6	157.8	106.4	86.0	90.3	104.7	56.7	46.3	49.0	55.6
Prince Edward Island, Canada	383.8	308.6	311.9	385.9	260.4	211.8	215.3	264.9	144.9	122.3	125.2	148.1	97.3	83.3	85.5	99.4	52.1	45.0	46.4	53.3
Portland, Oregon	377.2	305.8	308.6	380.2	256.6	210.6	213.6	262.0	143.3	121.9	124.3	147.3	96.3	83.0	84.9	99.0	51.7	44.9	46.1	53.1
Pyrenee Mountains	396.2	311.0	318.0	396.4	268.7	212.2	219.1	270.6	149.1	122.0	127.4	150.4	99.9	82.9	87.0	100.7	53.5	44.8	47.3	53.9
Quito, Ecuador	427.9	325.9	332.7	423.4	285.9	220.3	227.2	284.3	156.5	125.8	131.2	154.9	104.5	85.3	89.5	103.0	55.8	46.0	48.5	54.8
Santiago, Chile	356.0	295.2	298.1	362.0	245.4	204.9	207.9	253.0	138.7	119.3	121.7	144.6	93.5	81.4	83.2	97.8	50.2	44.1	45.2	52.7
Spokane, Washington	367.6	296.0	303.0	371.4	253.0	203.9	210.7	258.2	142.5	118.0	123.3	146.5	96.0	80.4	84.4	98.9	51.5	43.5	45.9	53.2
Tangmai, Tibet	428.3	323.6	330.6	425.4	291.7	218.8	225.7	288.1	161.2	124.9	130.4	158.3	107.7	84.7	88.9	105.5	57.6	45.7	48.2	56.3
Tehran, Iran	340.3	275.9	286.1	342.0	240.3	191.7	201.4	241.8	138.5	111.7	119.0	140.0	93.9	76.2	81.8	95.2	50.6	41.3	44.6	51.5
Tucson, Arizona	404.8	310.5	321.2	402.3	274.6	210.6	220.9	273.9	152.3	120.5	128.4	151.5	102.1	81.8	87.8	101.2	54.6	44.1	47.7	54.1
Ural Mountains	370.8	301.8	304.9	375.1	254.2	208.1	211.3	259.7	142.5	120.6	123.1	146.7	95.7	82.1	84.1	98.8	51.3	44.5	45.7	53.1
Xining, China	401.5	311.6	317.6	398.5	276.2	212.6	218.6	272.7	154.5	122.2	126.9	151.8	103.7	83.1	86.7	101.7	55.5	44.9	47.0	54.4

Time Delay (ns)
November
using ECM Data and Hopfield, Goad and Exponential Models
(Models use ECM Surface Data)

AOI	Elevation Angle = 0.0°				Elevation Angle = 1.0°				Elevation Angle = 3.0°				Elevation Angle = 5.0°				Elevation Angle = 10.0°			
	ECM	Hopfld	Goad	Exp	ECM	Hopfld	Goad	Exp	ECM	Hopfld	Goad	Exp	ECM	Hopfld	Goad	Exp	ECM	Hopfld	Goad	Exp
Ahaggar, Algeria	339.6	278.0	287.2	343.2	239.3	193.5	202.3	242.9	137.7	112.8	119.5	140.9	93.3	77.0	82.1	95.9	50.3	41.8	44.7	51.9
Bering Sea	344.5	294.2	291.5	350.9	238.7	205.5	203.2	245.7	134.8	120.1	118.6	140.4	90.7	82.1	81.0	95.0	48.7	44.5	43.9	51.2
Albuquerque, New Mexico	350.6	289.1	294.7	355.6	243.5	200.8	206.1	249.3	138.4	116.9	121.0	143.0	93.4	79.8	82.9	96.9	50.2	43.2	45.1	52.3
Alberta, Canada	350.0	296.7	294.8	355.8	243.0	207.1	205.5	248.7	137.5	121.1	120.0	142.2	92.6	82.7	82.0	96.3	49.7	44.9	44.5	51.9
Alp Mountains	362.3	300.6	301.7	367.5	249.4	208.4	209.7	255.5	140.3	121.2	122.4	145.1	94.4	82.7	83.6	98.0	50.7	44.8	45.4	52.7
Amazon Forest	425.4	323.9	331.4	422.6	285.4	218.8	226.3	284.5	156.4	124.9	130.7	155.3	104.4	84.7	89.2	103.3	55.7	45.7	48.4	55.0
Aguas, Mexico	389.6	306.5	314.2	388.9	267.3	209.5	217.1	266.2	149.3	120.6	126.5	148.3	100.2	82.0	86.5	99.4	53.7	44.3	47.0	53.2
GIUK (Grnland, Iceland, UK)	350.6	296.0	294.8	356.4	242.1	206.1	205.2	248.8	136.5	120.2	119.8	141.8	91.9	82.1	81.8	95.9	49.3	44.5	44.4	51.6
Baghdad, Iraq	353.3	289.8	295.4	358.3	246.4	201.1	206.5	251.1	140.1	117.1	121.3	144.0	94.5	79.9	83.1	97.6	50.8	43.3	45.2	52.6
Bangkok, Thailand	426.3	324.0	331.8	423.6	285.9	218.8	226.5	285.0	156.6	124.8	130.8	155.5	104.5	84.6	89.2	103.4	55.8	45.6	48.4	55.0
Cape Town, South Africa	378.0	306.9	309.7	380.4	254.3	211.1	214.1	261.6	141.4	122.1	124.6	146.6	95.0	83.2	85.1	98.5	50.9	45.0	46.2	52.8
Washington, D.C.	363.7	301.0	302.2	368.1	249.3	208.6	210.0	255.7	140.2	121.3	122.5	145.1	94.4	82.8	83.7	97.9	50.7	44.8	45.4	52.7
East Congo (Zaire)	435.5	327.3	336.1	430.9	291.3	220.3	229.0	288.5	159.1	125.4	132.1	156.4	106.0	85.0	90.1	103.8	56.6	45.8	48.9	55.2
Greenland	337.0	294.7	287.9	342.3	235.1	207.5	201.2	240.1	133.6	122.0	117.5	137.9	90.0	83.5	80.2	93.5	48.3	45.4	43.4	50.4
Hawaii Area	413.7	320.6	327.3	409.9	274.0	217.4	224.1	275.2	149.7	124.4	129.7	149.9	100.0	84.4	88.4	99.7	53.4	45.6	48.0	53.0
Huancayo, Peru	415.6	319.6	326.1	413.0	281.9	217.1	223.6	280.4	156.0	124.4	129.5	154.7	104.4	84.5	88.3	103.3	55.8	45.6	47.9	55.2
Indian Ocean (Diego Garcia)	427.6	324.7	332.0	424.2	286.6	219.2	226.6	285.5	157.0	125.0	130.8	155.7	104.8	84.8	89.2	103.5	55.9	45.7	48.4	55.1
Irkutsk, Siberia	347.7	300.3	295.5	354.1	241.9	210.8	206.4	248.1	137.1	123.7	120.6	142.2	92.3	84.6	82.3	96.4	49.6	45.9	44.6	52.0
Korea & Japan (Lower Sea of Japan)	359.2	299.6	300.7	364.3	246.3	208.0	209.3	253.4	138.6	121.1	122.2	144.0	93.4	82.6	83.5	97.3	50.1	44.8	45.3	52.3
Kabul, Afghanistan	347.7	286.7	292.8	352.6	242.9	199.3	205.2	248.0	138.6	116.2	120.7	142.7	93.6	79.3	82.7	96.8	50.4	43.0	45.0	52.3
Kashmir, India	363.0	295.5	301.3	367.4	250.6	204.2	209.8	255.7	141.4	118.5	122.9	145.4	95.3	80.7	84.1	98.2	51.2	43.7	45.7	52.9
LaPaz, Bolivia	384.9	305.0	311.6	384.7	264.3	209.0	215.5	264.2	148.0	120.5	125.6	147.8	99.4	82.0	85.9	99.2	53.3	44.3	46.6	53.2
Lhasa, Tibet (Himalayas)	354.8	291.9	297.1	358.8	247.0	202.7	207.8	251.3	140.4	118.0	122.0	143.9	94.8	80.5	83.6	97.5	51.0	43.6	45.4	52.6
Manaus, Brazil (Amazon Forest)	425.5	323.5	331.2	423.7	286.7	218.5	226.1	285.7	157.3	124.7	130.6	156.2	105.0	84.5	89.1	103.9	56.0	45.6	48.3	55.3
Manila, Philippines	432.9	327.1	335.3	428.1	287.9	220.4	228.5	285.9	156.8	125.5	131.8	154.6	104.5	85.1	89.8	102.5	55.7	45.8	48.7	54.4
Miami, Florida	407.9	318.5	324.6	405.0	271.0	216.5	222.6	273.3	148.6	124.1	129.0	149.9	99.4	84.3	88.0	99.8	53.1	45.5	47.7	53.2
Northwest Africa: Morocco	375.3	303.5	308.7	378.8	256.2	208.7	213.8	261.6	143.3	120.7	124.7	147.3	96.3	82.2	85.3	99.1	51.6	44.5	46.3	53.2
Moscow, Russia	345.9	298.4	292.8	351.9	240.0	209.4	204.3	246.4	135.9	122.8	119.2	141.2	91.6	84.0	81.3	95.6	49.2	45.6	44.1	51.6
Alaska	344.7	294.2	291.7	351.1	238.8	205.4	203.3	245.8	134.9	120.1	118.7	140.5	90.8	82.0	81.0	95.0	48.7	44.5	43.9	51.2
Northern Australia: Tanami Desert	363.8	289.0	299.2	364.9	254.1	198.9	208.7	254.6	144.4	115.1	122.6	145.0	97.4	78.4	84.0	98.0	52.3	42.4	45.7	52.8
New Guinea	446.3	333.3	340.9	441.8	296.5	224.0	231.6	294.6	161.0	127.3	133.3	159.1	107.2	86.2	90.8	105.4	57.1	46.5	49.2	56.0
Prince Edward Island, Canada	350.1	297.8	294.8	355.6	241.9	208.0	205.4	248.5	136.8	121.7	119.9	142.0	92.2	83.1	81.9	96.1	49.5	45.1	44.4	51.8
Portland, Oregon	360.5	299.6	300.6	366.0	247.7	207.8	208.9	254.5	139.3	120.9	121.9	144.5	93.7	82.5	83.3	97.6	50.3	44.7	45.2	52.5
Pyrenee Mountains	367.5	302.4	304.3	372.0	252.2	209.1	211.2	257.8	141.6	121.4	123.2	145.9	95.2	82.8	84.1	98.4	51.1	44.8	45.7	52.9
Quito, Ecuador	434.3	328.5	335.2	430.0	291.0	221.8	228.5	288.3	159.2	126.5	131.8	156.8	106.2	85.8	89.8	104.2	56.6	46.2	48.7	55.4
Santiago, Chile	362.3	297.1	301.2	367.3	247.9	205.5	209.6	255.5	139.5	119.3	122.5	145.2	94.0	81.3	83.8	98.0	50.5	44.0	45.5	52.7
Spokane, Washington	353.8	297.7	296.9	359.3	244.8	207.4	206.8	250.9	138.3	121.0	120.8	143.2	93.1	82.7	82.5	96.9	50.0	44.8	44.8	52.2
Tangmai, Tibet	385.4	307.5	312.7	385.3	263.5	211.0	216.2	264.0	147.1	121.8	125.9	147.3	98.7	82.9	86.0	98.8	52.9	44.8	46.7	52.9
Tehran, Iran	361.5	295.0	300.4	365.7	250.4	204.1	209.4	255.0	141.6	118.5	122.7	145.3	95.4	80.8	84.0	98.2	51.3	43.8	45.7	52.9
Tucson, Arizona	360.6	294.1	300.2	365.7	247.3	203.1	209.1	254.8	139.4	117.8	122.4	145.0	93.9	80.3	83.8	97.9	50.5	43.5	45.6	52.7
Ural Mountains	344.6	301.0	292.4	350.7	239.0	211.8	203.9	245.4	135.3	124.5	118.7	140.5	91.1	85.2	80.9	95.2	48.9	46.3	43.8	51.3
Xining, China	362.6	299.1	301.7	367.0	250.7	207.4	210.1	255.7	141.6	120.7	122.8	145.6	95.3	82.3	84.0	98.4	51.2	44.6	45.6	53.0

Angle Error (deg)
February
using ECM Data, Goad Model and Exponential Model
(Models use ECM Surface Data)

AOI	Elevation Angle = 0.0°			Elevation Angle = 1.0°			Elevation Angle =3.0°			Elevation Angle = 5.0°			Elevation Angle = 10.0°		
	ECM	Goad	Exp	ECM	Goad	Exp	ECM	Goad	Exp	ECM	Goad	Exp	ECM	Goad	Exp
Ahaggar, Algeria	0.2552	0.5342	0.2603	0.2300	0.3963	0.2312	0.1527	0.2392	0.1512	0.1077	0.1657	0.1061	0.0592	0.0902	0.0581
Bering Sea	0.2992	0.6008	0.2901	0.2724	0.4391	0.2652	0.1761	0.2611	0.1718	0.1228	0.1797	0.1198	0.0669	0.0972	0.0652
Albuquerque, New Mexico	0.3136	0.6119	0.3015	0.2743	0.4435	0.2652	0.1755	0.2627	0.1710	0.1222	0.1808	0.1194	0.0666	0.0979	0.0651
Alberta, Canada	0.3134	0.6100	0.3089	0.2758	0.4456	0.2706	0.1772	0.2649	0.1733	0.1235	0.1823	0.1207	0.0673	0.0987	0.0657
Alp Mountains	0.3372	0.6403	0.3198	0.2910	0.4619	0.2798	0.1840	0.2724	0.1789	0.1277	0.1870	0.1245	0.0694	0.1011	0.0677
Amazon Forest	0.4606	0.8631	0.4417	0.3877	0.5907	0.3789	0.2367	0.3341	0.2362	0.1619	0.2263	0.1626	0.0871	0.1212	0.0876
Aguas, Mexico	0.3335	0.6773	0.3359	0.2942	0.4810	0.2935	0.1886	0.2806	0.1877	0.1312	0.1922	0.1305	0.0713	0.1037	0.0709
GIUK (Grnland, Iceland, UK)	0.3205	0.6231	0.3040	0.2816	0.4514	0.2706	0.1797	0.2669	0.1746	0.1249	0.1834	0.1216	0.0679	0.0991	0.0662
Baghdad, Iraq	0.3162	0.6143	0.3040	0.2755	0.4454	0.2672	0.1762	0.2638	0.1720	0.1228	0.1815	0.1200	0.0669	0.0982	0.0654
Bangkok, Thailand	0.4833	0.8558	0.4405	0.3975	0.5862	0.3781	0.2383	0.3319	0.2357	0.1623	0.2249	0.1621	0.0870	0.1205	0.0874
Cape Town, South Africa	0.4307	0.7370	0.3724	0.3517	0.5167	0.3230	0.2115	0.2982	0.2046	0.1447	0.2034	0.1417	0.0779	0.1095	0.0768
Washington, D.C.	0.3325	0.6186	0.3107	0.2850	0.4496	0.2723	0.1797	0.2666	0.1746	0.1248	0.1833	0.1217	0.0678	0.0992	0.0662
East Congo (Zaire)	0.4590	0.8781	0.4485	0.3891	0.5994	0.3851	0.2389	0.3383	0.2400	0.1637	0.2290	0.1650	0.0880	0.1226	0.0889
Greenland	0.2870	0.5744	0.2875	0.2575	0.4265	0.2561	0.1680	0.2561	0.1652	0.1174	0.1766	0.1151	0.0641	0.0956	0.0626
Hawaii Area	0.4767	0.8052	0.4149	0.3851	0.5566	0.3563	0.2282	0.3176	0.2228	0.1552	0.2158	0.1536	0.0832	0.1158	0.0829
Huancayo, Peru	0.4245	0.8424	0.4281	0.3648	0.5789	0.3670	0.2275	0.3286	0.2291	0.1568	0.2229	0.1580	0.0847	0.1195	0.0853
Indian Ocean (Diego Garcia)	0.4651	0.8690	0.4406	0.3899	0.5940	0.3788	0.2377	0.3357	0.2366	0.1626	0.2273	0.1629	0.0874	0.1217	0.0878
Irkutsk, Siberia	0.3105	0.5968	0.3122	0.2759	0.4420	0.2737	0.1772	0.2649	0.1738	0.1237	0.1826	0.1209	0.0674	0.0988	0.0658
Korea & Japan (Lower Sea of Japan)	0.3303	0.6136	0.3129	0.2844	0.4474	0.2737	0.1796	0.2658	0.1749	0.1247	0.1829	0.1218	0.0678	0.0990	0.0663
Kabul, Afghanistan	0.3265	0.6342	0.3153	0.2840	0.4572	0.2764	0.1809	0.2696	0.1772	0.1259	0.1852	0.1234	0.0685	0.1002	0.0672
Kashmir, India	0.3493	0.6631	0.3291	0.2999	0.4739	0.2878	0.1888	0.2776	0.1841	0.1309	0.1903	0.1281	0.0710	0.1028	0.0697
LaPaz, Bolivia	0.3949	0.7719	0.3908	0.3396	0.5370	0.3375	0.2123	0.3080	0.2127	0.1465	0.2097	0.1471	0.0792	0.1127	0.0796
Lhasa, Tibet (Himalayas)	0.3109	0.6154	0.3038	0.2722	0.4457	0.2669	0.1750	0.2638	0.1719	0.1222	0.1815	0.1200	0.0666	0.0982	0.0654
Manaus, Brazil (Amazon Forest)	0.4714	0.8809	0.4461	0.3945	0.6010	0.3835	0.2403	0.3391	0.2393	0.1643	0.2295	0.1647	0.0883	0.1228	0.0888
Manila, Philippines	0.4821	0.8388	0.4279	0.3914	0.5763	0.3678	0.2338	0.3270	0.2300	0.1593	0.2218	0.1584	0.0855	0.1189	0.0855
Miami, Florida	0.4464	0.7612	0.3872	0.3625	0.5313	0.3342	0.2166	0.3055	0.2102	0.1479	0.2081	0.1453	0.0795	0.1119	0.0786
Northwest Africa: Morocco	0.3631	0.6787	0.3367	0.3094	0.4831	0.2938	0.1927	0.2822	0.1872	0.1332	0.1933	0.1302	0.0722	0.1043	0.0707
Moscow, Russia	0.3213	0.5996	0.3083	0.2785	0.4427	0.2698	0.1770	0.2648	0.1723	0.1231	0.1824	0.1199	0.0670	0.0987	0.0652
Alaska	0.2998	0.6018	0.2900	0.2729	0.4396	0.2653	0.1763	0.2613	0.1719	0.1229	0.1798	0.1198	0.0669	0.0973	0.0653
Northern Australia: Tanami Desert	0.3459	0.7203	0.3512	0.3061	0.5054	0.3086	0.1966	0.2920	0.1976	0.1367	0.1993	0.1373	0.0742	0.1074	0.0745
New Guinea	0.4751	0.9018	0.4610	0.4002	0.6136	0.3940	0.2445	0.3454	0.2447	0.1673	0.2335	0.1682	0.0900	0.1249	0.0906
Prince Edward Island, Canada	0.3197	0.5986	0.3062	0.2773	0.4405	0.2684	0.1766	0.2630	0.1722	0.1229	0.1811	0.1200	0.0669	0.0980	0.0653
Portland, Oregon	0.3607	0.6584	0.3282	0.3046	0.4722	0.2869	0.1896	0.2772	0.1833	0.1311	0.1901	0.1275	0.0711	0.1026	0.0693
Pyrenee Mountains	0.3476	0.6544	0.3268	0.2986	0.4699	0.2856	0.1876	0.2762	0.1823	0.1300	0.1895	0.1268	0.0706	0.1023	0.0689
Quito, Ecuador	0.4605	0.8623	0.4459	0.3868	0.5905	0.3808	0.2361	0.3342	0.2366	0.1617	0.2264	0.1627	0.0870	0.1213	0.0877
Santiago, Chile	0.3959	0.6950	0.3472	0.3278	0.4918	0.3031	0.2000	0.2858	0.1935	0.1374	0.1955	0.1344	0.0742	0.1054	0.0730
Spokane, Washington	0.3293	0.6290	0.3154	0.2857	0.4558	0.2761	0.1815	0.2696	0.1767	0.1262	0.1853	0.1231	0.0686	0.1002	0.0670
Tangmai, Tibet	0.3589	0.7000	0.3540	0.3112	0.4952	0.3077	0.1964	0.2879	0.1952	0.1360	0.1969	0.1354	0.0738	0.1061	0.0735
Tehran, Iran	0.3372	0.6561	0.3293	0.2946	0.4702	0.2877	0.1871	0.2760	0.1836	0.1299	0.1893	0.1277	0.0706	0.1023	0.0694
Tucson, Arizona	0.3333	0.6249	0.3043	0.2846	0.4505	0.2680	0.1792	0.2658	0.1731	0.1243	0.1827	0.1208	0.0676	0.0989	0.0658
Ural Mountains	0.3284	0.6018	0.3120	0.2828	0.4455	0.2727	0.1787	0.2667	0.1737	0.1241	0.1836	0.1208	0.0675	0.0993	0.0657
Xining, China	0.3209	0.6251	0.3099	0.2794	0.4523	0.2719	0.1787	0.2675	0.1746	0.1245	0.1839	0.1217	0.0678	0.0995	0.0663

Angle Error (deg)
May
using ECM Data, Goad Model and Exponential Model
(Models use ECM Surface Data)

AOI	Elevation Angle = 0.0°			Elevation Angle = 1.0°			Elevation Angle =3.0°			Elevation Angle = 5.0°			Elevation Angle = 10.0°		
	ECM	Goad	Exp	ECM	Goad	Exp	ECM	Goad	Exp	ECM	Goad	Exp	ECM	Goad	Exp
Ahaggar, Algeria	0.2748	0.5708	0.2688	0.2428	0.4158	0.2399	0.1596	0.2478	0.1575	0.1123	0.1711	0.1105	0.0616	0.0929	0.0605
Bering Sea	0.3267	0.6242	0.3133	0.2845	0.4529	0.2755	0.1816	0.2680	0.1772	0.1263	0.1842	0.1235	0.0687	0.0996	0.0672
Albuquerque, New Mexico	0.3116	0.6182	0.2982	0.2719	0.4453	0.2638	0.1750	0.2628	0.1712	0.1221	0.1807	0.1197	0.0666	0.0978	0.0653
Alberta, Canada	0.3521	0.6735	0.3364	0.3042	0.4801	0.2939	0.1921	0.2807	0.1878	0.1332	0.1922	0.1306	0.0723	0.1037	0.0710
Alp Mountains	0.3765	0.7085	0.3549	0.3219	0.5002	0.3090	0.2010	0.2903	0.1965	0.1388	0.1983	0.1364	0.0752	0.1069	0.0740
Amazon Forest	0.4729	0.8730	0.4506	0.3956	0.5966	0.3854	0.2402	0.3371	0.2397	0.1642	0.2282	0.1648	0.0882	0.1222	0.0888
Aguas, Mexico	0.3391	0.6905	0.3402	0.2989	0.4882	0.2977	0.1915	0.2839	0.1908	0.1332	0.1942	0.1327	0.0724	0.1048	0.0721
GIUK (Grnland, Iceland, UK)	0.3447	0.6472	0.3246	0.2964	0.4658	0.2841	0.1871	0.2741	0.1820	0.1298	0.1881	0.1267	0.0705	0.1016	0.0689
Baghdad, Iraq	0.3130	0.6413	0.3053	0.2765	0.4584	0.2712	0.1791	0.2689	0.1762	0.1250	0.1846	0.1231	0.0682	0.0998	0.0671
Bangkok, Thailand	0.4859	0.8894	0.4495	0.4043	0.6060	0.3877	0.2444	0.3414	0.2422	0.1668	0.2309	0.1666	0.0895	0.1236	0.0898
Cape Town, South Africa	0.4302	0.7252	0.3652	0.3475	0.5103	0.3168	0.2084	0.2953	0.2006	0.1426	0.2016	0.1391	0.0768	0.1085	0.0754
Washington, D.C.	0.3935	0.7232	0.3640	0.3319	0.5086	0.3162	0.2049	0.2943	0.2006	0.1411	0.2009	0.1391	0.0763	0.1082	0.0754
East Congo (Zaire)	0.4738	0.8853	0.4580	0.3993	0.6038	0.3918	0.2433	0.3405	0.2435	0.1663	0.2304	0.1673	0.0893	0.1233	0.0901
Greenland	0.3178	0.6083	0.3104	0.2775	0.4444	0.2719	0.1781	0.2642	0.1745	0.1243	0.1819	0.1216	0.0677	0.0984	0.0662
Hawaii Area	0.4853	0.8176	0.4264	0.3910	0.5641	0.3650	0.2316	0.3213	0.2274	0.1575	0.2182	0.1566	0.0845	0.1171	0.0845
Huancayo, Peru	0.4481	0.8535	0.4440	0.3788	0.5857	0.3788	0.2329	0.3321	0.2349	0.1600	0.2251	0.1616	0.0862	0.1206	0.0872
Indian Ocean (Diego Garcia)	0.4661	0.8645	0.4422	0.3902	0.5915	0.3795	0.2376	0.3345	0.2368	0.1625	0.2266	0.1629	0.0874	0.1213	0.0879
Irkutsk, Siberia	0.3458	0.6648	0.3306	0.2996	0.4750	0.2892	0.1897	0.2782	0.1852	0.1317	0.1907	0.1289	0.0715	0.1029	0.0701
Korea & Japan (Lower Sea of Japan)	0.3944	0.7062	0.3538	0.3285	0.4987	0.3085	0.2018	0.2895	0.1965	0.1389	0.1978	0.1364	0.0750	0.1066	0.0740
Kabul, Afghanistan	0.3114	0.6269	0.3017	0.2742	0.4504	0.2672	0.1768	0.2652	0.1735	0.1234	0.1822	0.1212	0.0673	0.0986	0.0661
Kashmir, India	0.3598	0.7087	0.3478	0.3125	0.4988	0.3055	0.1977	0.2889	0.1957	0.1370	0.1974	0.1360	0.0743	0.1064	0.0739
LaPaz, Bolivia	0.3811	0.7319	0.3717	0.3275	0.5136	0.3220	0.2046	0.2967	0.2036	0.1413	0.2024	0.1410	0.0765	0.1090	0.0765
Lhasa, Tibet (Himalayas)	0.3681	0.7086	0.3534	0.3150	0.4999	0.3074	0.1977	0.2900	0.1956	0.1369	0.1982	0.1359	0.0743	0.1068	0.0738
Manaus, Brazil (Amazon Forest)	0.4596	0.8751	0.4477	0.3897	0.5977	0.3840	0.2391	0.3375	0.2394	0.1637	0.2285	0.1647	0.0881	0.1223	0.0888
Manila, Philippines	0.4752	0.8667	0.4402	0.3959	0.5926	0.3792	0.2396	0.3349	0.2371	0.1635	0.2268	0.1632	0.0878	0.1215	0.0880
Miami, Florida	0.4687	0.8084	0.4165	0.3831	0.5586	0.3578	0.2289	0.3185	0.2239	0.1560	0.2164	0.1544	0.0837	0.1161	0.0834
Northwest Africa: Morocco	0.3753	0.7114	0.3483	0.3190	0.5012	0.3038	0.1985	0.2905	0.1938	0.1370	0.1985	0.1346	0.0742	0.1070	0.0731
Moscow, Russia	0.3464	0.6559	0.3251	0.2976	0.4698	0.2847	0.1879	0.2757	0.1825	0.1304	0.1891	0.1271	0.0708	0.1021	0.0692
Alaska	0.3281	0.6260	0.3141	0.2855	0.4539	0.2761	0.1821	0.2685	0.1776	0.1266	0.1845	0.1238	0.0689	0.0997	0.0674
Northern Australia: Tanami Desert	0.3155	0.6358	0.3143	0.2794	0.4569	0.2759	0.1797	0.2690	0.1775	0.1253	0.1848	0.1237	0.0682	0.0999	0.0674
New Guinea	0.5118	0.9327	0.4871	0.4230	0.6320	0.4135	0.2546	0.3544	0.2549	0.1736	0.2393	0.1748	0.0931	0.1279	0.0940
Prince Edward Island, Canada	0.3431	0.6488	0.3240	0.2955	0.4664	0.2838	0.1866	0.2743	0.1820	0.1295	0.1882	0.1267	0.0704	0.1016	0.0690
Portland, Oregon	0.3696	0.6717	0.3373	0.3119	0.4797	0.2942	0.1935	0.2807	0.1876	0.1336	0.1923	0.1304	0.0724	0.1038	0.0709
Pyrenee Mountains	0.3671	0.6984	0.3497	0.3162	0.4942	0.3047	0.1984	0.2874	0.1940	0.1372	0.1965	0.1347	0.0744	0.1059	0.0732
Quito, Ecuador	0.4828	0.8932	0.4650	0.4028	0.6089	0.3956	0.2443	0.3433	0.2447	0.1670	0.2322	0.1681	0.0898	0.1243	0.0905
Santiago, Chile	0.3652	0.6644	0.3288	0.3073	0.4745	0.2876	0.1905	0.2779	0.1842	0.1316	0.1905	0.1282	0.0713	0.1028	0.0697
Spokane, Washington	0.3588	0.6745	0.3368	0.3075	0.4804	0.2942	0.1929	0.2808	0.1880	0.1336	0.1923	0.1307	0.0724	0.1038	0.0710
Tangmai, Tibet	0.4336	0.8348	0.4292	0.3691	0.5741	0.3683	0.2286	0.3260	0.2301	0.1571	0.2212	0.1585	0.0847	0.1186	0.0856
Tehran, Iran	0.3588	0.6917	0.3429	0.3081	0.4894	0.2995	0.1942	0.2846	0.1915	0.1346	0.1947	0.1331	0.0730	0.1050	0.0724
Tucson, Arizona	0.3649	0.6721	0.3275	0.3091	0.4773	0.2884	0.1922	0.2784	0.1858	0.1326	0.1907	0.1294	0.0718	0.1029	0.0704
Ural Mountains	0.3324	0.6309	0.3152	0.2870	0.4561	0.2765	0.1825	0.2693	0.1777	0.1269	0.1850	0.1238	0.0691	0.1000	0.0674
Xining, China	0.3911	0.7555	0.3809	0.3338	0.5274	0.3298	0.2089	0.3034	0.2084	0.1444	0.2067	0.1443	0.0782	0.1112	0.0782

Angle Error (deg)
August
using ECM Data, Goad Model and Exponential Model
(Models use ECM Surface Data)

AOI	Elevation Angle = 0.0°			Elevation Angle = 1.0°			Elevation Angle =3.0°			Elevation Angle = 5.0°			Elevation Angle = 10.0°		
	ECM	Goad	Exp	ECM	Goad	Exp	ECM	Goad	Exp	ECM	Goad	Exp	ECM	Goad	Exp
Ahaggar, Algeria	0.3088	0.6279	0.3004	0.2712	0.4497	0.2659	0.1752	0.2644	0.1728	0.1224	0.1817	0.1208	0.0668	0.0984	0.0659
Bering Sea	0.3405	0.6718	0.3366	0.2993	0.4796	0.2944	0.1912	0.2805	0.1885	0.1329	0.1921	0.1312	0.0722	0.1037	0.0714
Albuquerque, New Mexico	0.3982	0.7834	0.3944	0.3414	0.5433	0.3411	0.2144	0.3108	0.2154	0.1482	0.2115	0.1491	0.0803	0.1136	0.0807
Alberta, Canada	0.3673	0.7120	0.3583	0.3182	0.5019	0.3117	0.2008	0.2909	0.1983	0.1391	0.1987	0.1377	0.0755	0.1071	0.0748
Alp Mountains	0.4093	0.7563	0.3846	0.3459	0.5279	0.3327	0.2134	0.3036	0.2100	0.1469	0.2069	0.1454	0.0793	0.1113	0.0788
Amazon Forest	0.4533	0.8408	0.4331	0.3806	0.5776	0.3713	0.2323	0.3278	0.2317	0.1590	0.2223	0.1596	0.0856	0.1192	0.0861
Aguas, Mexico	0.4264	0.8455	0.4327	0.3674	0.5805	0.3710	0.2295	0.3293	0.2317	0.1582	0.2233	0.1597	0.0854	0.1197	0.0863
GIUK (Grnland, Iceland, UK)	0.3646	0.6856	0.3442	0.3129	0.4874	0.3006	0.1964	0.2842	0.1920	0.1359	0.1945	0.1335	0.0737	0.1049	0.0726
Baghdad, Iraq	0.2734	0.6164	0.2808	0.2565	0.4421	0.2592	0.1705	0.2602	0.1703	0.1197	0.1789	0.1192	0.0655	0.0969	0.0651
Bangkok, Thailand	0.4732	0.8701	0.4365	0.3939	0.5945	0.3774	0.2391	0.3358	0.2366	0.1634	0.2273	0.1630	0.0878	0.1217	0.0879
Cape Town, South Africa	0.4154	0.7085	0.3555	0.3386	0.5009	0.3090	0.2041	0.2910	0.1959	0.1400	0.1989	0.1359	0.0755	0.1071	0.0738
Washington, D.C.	0.4687	0.8350	0.4342	0.3872	0.5744	0.3717	0.2337	0.3264	0.2316	0.1597	0.2214	0.1595	0.0859	0.1187	0.0861
East Congo (Zaire)	0.4355	0.8314	0.4221	0.3681	0.5718	0.3633	0.2272	0.3248	0.2277	0.1561	0.2204	0.1570	0.0842	0.1182	0.0848
Greenland	0.3247	0.6300	0.3151	0.2837	0.4553	0.2769	0.1821	0.2688	0.1783	0.1269	0.1846	0.1243	0.0691	0.0998	0.0677
Hawaii Area	0.4990	0.8435	0.4440	0.4032	0.5793	0.3780	0.2385	0.3287	0.2352	0.1621	0.2229	0.1617	0.0868	0.1195	0.0872
Huancayo, Peru	0.4198	0.8055	0.4139	0.3571	0.5572	0.3553	0.2213	0.3181	0.2221	0.1524	0.2162	0.1533	0.0823	0.1161	0.0828
Indian Ocean (Diego Garcia)	0.4449	0.8336	0.4265	0.3760	0.5732	0.3667	0.2305	0.3256	0.2295	0.1580	0.2209	0.1582	0.0850	0.1184	0.0854
Irkutsk, Siberia	0.3814	0.7373	0.3702	0.3291	0.5165	0.3222	0.2068	0.2979	0.2047	0.1430	0.2031	0.1419	0.0775	0.1093	0.0770
Korea & Japan (Lower Sea of Japan)	0.4763	0.8570	0.4397	0.3954	0.5868	0.3790	0.2389	0.3321	0.2369	0.1630	0.2250	0.1631	0.0876	0.1205	0.0880
Kabul, Afghanistan	0.2889	0.6177	0.2890	0.2632	0.4438	0.2627	0.1725	0.2614	0.1718	0.1208	0.1797	0.1202	0.0660	0.0973	0.0656
Kashmir, India	0.4401	0.8770	0.4443	0.3825	0.5984	0.3865	0.2382	0.3375	0.2417	0.1637	0.2284	0.1663	0.0882	0.1223	0.0897
LaPaz, Bolivia	0.3676	0.7149	0.3623	0.3184	0.5036	0.3144	0.2002	0.2918	0.1993	0.1386	0.1994	0.1382	0.0751	0.1074	0.0750
Lhasa, Tibet (Himalayas)	0.3797	0.7795	0.3830	0.3304	0.5414	0.3323	0.2102	0.3101	0.2108	0.1459	0.2110	0.1462	0.0792	0.1134	0.0793
Manaus, Brazil (Amazon Forest)	0.4413	0.8451	0.4350	0.3782	0.5799	0.3736	0.2331	0.3288	0.2334	0.1598	0.2229	0.1607	0.0860	0.1195	0.0867
Manila, Philippines	0.4613	0.8682	0.4364	0.3893	0.5934	0.3772	0.2381	0.3353	0.2364	0.1630	0.2270	0.1629	0.0877	0.1216	0.0879
Miami, Florida	0.5529	0.8978	0.4705	0.4315	0.6116	0.4000	0.2513	0.3445	0.2471	0.1703	0.2330	0.1696	0.0911	0.1247	0.0913
Northwest Africa: Morocco	0.4046	0.7744	0.3764	0.3407	0.5381	0.3267	0.2105	0.3083	0.2073	0.1450	0.2099	0.1437	0.0784	0.1128	0.0779
Moscow, Russia	0.3626	0.6991	0.3481	0.3140	0.4943	0.3042	0.1982	0.2872	0.1944	0.1373	0.1964	0.1351	0.0745	0.1058	0.0734
Alaska	0.3425	0.6728	0.3377	0.3005	0.4802	0.2952	0.1917	0.2809	0.1889	0.1332	0.1924	0.1314	0.0724	0.1038	0.0715
Northern Australia: Tanami Desert	0.2990	0.6010	0.2980	0.2648	0.4366	0.2622	0.1713	0.2592	0.1693	0.1198	0.1785	0.1183	0.0654	0.0967	0.0645
New Guinea	0.4973	0.9075	0.4712	0.4117	0.6172	0.4011	0.2486	0.3472	0.2482	0.1697	0.2347	0.1704	0.0911	0.1255	0.0918
Prince Edward Island, Canada	0.4107	0.7414	0.3758	0.3441	0.5195	0.3257	0.2110	0.2997	0.2062	0.1450	0.2044	0.1428	0.0783	0.1099	0.0774
Portland, Oregon	0.4015	0.7171	0.3634	0.3355	0.5056	0.3155	0.2056	0.2931	0.2002	0.1414	0.2002	0.1389	0.0764	0.1078	0.0754
Pyrenee Mountains	0.4198	0.7744	0.3962	0.3538	0.5386	0.3418	0.2176	0.3089	0.2150	0.1496	0.2103	0.1487	0.0808	0.1130	0.0805
Quito, Ecuador	0.4803	0.8694	0.4521	0.3962	0.5948	0.3854	0.2394	0.3364	0.2389	0.1636	0.2278	0.1643	0.0880	0.1220	0.0886
Santiago, Chile	0.3500	0.6452	0.3201	0.2976	0.4635	0.2804	0.1860	0.2727	0.1798	0.1288	0.1872	0.1253	0.0699	0.1012	0.0682
Spokane, Washington	0.3619	0.6827	0.3381	0.3087	0.4841	0.2958	0.1938	0.2821	0.1895	0.1343	0.1931	0.1319	0.0729	0.1042	0.0717
Tangmai, Tibet	0.4234	0.8643	0.4335	0.3679	0.5913	0.3737	0.2317	0.3343	0.2344	0.1599	0.2264	0.1617	0.0865	0.1213	0.0873
Tehran, Iran	0.2763	0.5817	0.2790	0.2474	0.4229	0.2489	0.1632	0.2514	0.1629	0.1148	0.1734	0.1142	0.0629	0.0941	0.0624
Tucson, Arizona	0.4216	0.8005	0.4016	0.3569	0.5531	0.3487	0.2211	0.3154	0.2204	0.1521	0.2144	0.1523	0.0821	0.1151	0.0824
Ural Mountains	0.3709	0.7004	0.3491	0.3180	0.4953	0.3052	0.1995	0.2877	0.1950	0.1380	0.1967	0.1355	0.0748	0.1060	0.0736
Xining, China	0.3793	0.7793	0.3911	0.3306	0.5413	0.3386	0.2110	0.3100	0.2141	0.1465	0.2109	0.1482	0.0795	0.1133	0.0803

Angle Error (deg)
November
using ECM Data, Goad Model and Exponential Model
(Models use ECM Surface Data)

AOI	Elevation Angle = 0.0°			Elevation Angle = 1.0°			Elevation Angle =3.0°			Elevation Angle = 5.0°			Elevation Angle = 10.0°		
	ECM	Goad	Exp	ECM	Goad	Exp	ECM	Goad	Exp	ECM	Goad	Exp	ECM	Goad	Exp
Ahaggar, Algeria	0.2814	0.5789	0.2799	0.2491	0.4221	0.2477	0.1630	0.2516	0.1612	0.1145	0.1736	0.1129	0.0627	0.0942	0.0617
Bering Sea	0.3184	0.6193	0.3031	0.2821	0.4492	0.2717	0.1805	0.2658	0.1755	0.1255	0.1827	0.1223	0.0682	0.0987	0.0666
Albuquerque, New Mexico	0.3256	0.6249	0.3077	0.2812	0.4507	0.2703	0.1785	0.2660	0.1741	0.1241	0.1829	0.1215	0.0675	0.0990	0.0662
Alberta, Canada	0.3195	0.6256	0.3143	0.2807	0.4536	0.2754	0.1801	0.2684	0.1765	0.1255	0.1845	0.1229	0.0683	0.0997	0.0669
Alp Mountains	0.3538	0.6687	0.3333	0.3035	0.4779	0.2909	0.1903	0.2799	0.1854	0.1317	0.1918	0.1289	0.0714	0.1035	0.0700
Amazon Forest	0.4647	0.8675	0.4427	0.3905	0.5932	0.3799	0.2381	0.3353	0.2371	0.1628	0.2271	0.1632	0.0876	0.1216	0.0880
Aguas, Mexico	0.3789	0.7504	0.3823	0.3302	0.5242	0.3304	0.2079	0.3018	0.2084	0.1437	0.2057	0.1442	0.0778	0.1107	0.0781
GIUK (Grnland, Iceland, UK)	0.3328	0.6381	0.3127	0.2895	0.4598	0.2769	0.1835	0.2708	0.1783	0.1272	0.1859	0.1241	0.0691	0.1004	0.0675
Baghdad, Iraq	0.3118	0.6294	0.3102	0.2765	0.4533	0.2726	0.1784	0.2673	0.1755	0.1245	0.1837	0.1224	0.0679	0.0994	0.0667
Bangkok, Thailand	0.4652	0.8703	0.4440	0.3922	0.5948	0.3815	0.2391	0.3361	0.2381	0.1635	0.2275	0.1638	0.0879	0.1218	0.0883
Cape Town, South Africa	0.4336	0.7249	0.3668	0.3496	0.5101	0.3180	0.2091	0.2952	0.2013	0.1430	0.2016	0.1395	0.0770	0.1085	0.0756
Washington, D.C.	0.3713	0.6711	0.3364	0.3119	0.4793	0.2934	0.1926	0.2806	0.1870	0.1330	0.1923	0.1300	0.0720	0.1038	0.0706
East Congo (Zaire)	0.4778	0.8958	0.4614	0.4013	0.6099	0.3948	0.2446	0.3435	0.2453	0.1672	0.2323	0.1685	0.0899	0.1243	0.0907
Greenland	0.2930	0.5788	0.2936	0.2601	0.4285	0.2586	0.1691	0.2569	0.1664	0.1182	0.1772	0.1159	0.0645	0.0960	0.0631
Hawaii Area	0.4953	0.8384	0.4389	0.4010	0.5762	0.3751	0.2372	0.3272	0.2331	0.1611	0.2219	0.1603	0.0863	0.1190	0.0864
Huancayo, Peru	0.4303	0.8262	0.4197	0.3636	0.5694	0.3603	0.2248	0.3240	0.2252	0.1548	0.2199	0.1554	0.0836	0.1180	0.0840
Indian Ocean (Diego Garcia)	0.4678	0.8734	0.4438	0.3924	0.5966	0.3817	0.2392	0.3369	0.2384	0.1636	0.2281	0.1640	0.0880	0.1221	0.0885
Irkutsk, Siberia	0.3132	0.6064	0.3107	0.2768	0.4452	0.2725	0.1772	0.2656	0.1735	0.1236	0.1829	0.1207	0.0673	0.0990	0.0657
Korea & Japan (Lower Sea of Japan)	0.3668	0.6591	0.3320	0.3083	0.4725	0.2896	0.1905	0.2774	0.1845	0.1316	0.1902	0.1283	0.0713	0.1027	0.0697
Kabul, Afghanistan	0.3079	0.6103	0.3005	0.2701	0.4420	0.2644	0.1738	0.2618	0.1705	0.1214	0.1802	0.1191	0.0662	0.0976	0.0649
Kashmir, India	0.3484	0.6672	0.3314	0.3004	0.4756	0.2897	0.1893	0.2782	0.1853	0.1312	0.1907	0.1289	0.0713	0.1030	0.0701
LaPaz, Bolivia	0.3759	0.7354	0.3718	0.3254	0.5155	0.3222	0.2044	0.2975	0.2039	0.1413	0.2030	0.1413	0.0765	0.1093	0.0766
Lhasa, Tibet (Himalayas)	0.3228	0.6311	0.3147	0.2815	0.4550	0.2758	0.1794	0.2685	0.1766	0.1250	0.1846	0.1231	0.0681	0.0999	0.0670
Manaus, Brazil (Amazon Forest)	0.4514	0.8676	0.4389	0.3855	0.5931	0.3781	0.2372	0.3352	0.2365	0.1625	0.2270	0.1629	0.0874	0.1216	0.0879
Manila, Philippines	0.4930	0.8921	0.4636	0.4099	0.6077	0.3964	0.2467	0.3424	0.2459	0.1681	0.2316	0.1688	0.0901	0.1239	0.0909
Miami, Florida	0.4848	0.8194	0.4246	0.3908	0.5652	0.3637	0.2314	0.3219	0.2267	0.1575	0.2186	0.1561	0.0844	0.1173	0.0843
Northwest Africa: Morocco	0.3873	0.7144	0.3562	0.3268	0.5036	0.3097	0.2016	0.2919	0.1966	0.1389	0.1995	0.1364	0.0751	0.1075	0.0740
Moscow, Russia	0.3190	0.6073	0.3065	0.2771	0.4447	0.2687	0.1766	0.2648	0.1722	0.1229	0.1822	0.1199	0.0669	0.0986	0.0653
Alaska	0.3187	0.6206	0.3031	0.2826	0.4499	0.2720	0.1807	0.2661	0.1757	0.1256	0.1828	0.1224	0.0683	0.0988	0.0666
Northern Australia: Tanami Desert	0.3134	0.6614	0.3212	0.2800	0.4704	0.2831	0.1825	0.2749	0.1827	0.1275	0.1884	0.1273	0.0696	0.1018	0.0693
New Guinea	0.5052	0.9254	0.4805	0.4196	0.6277	0.4087	0.2530	0.3523	0.2525	0.1725	0.2380	0.1733	0.0925	0.1272	0.0932
Prince Edward Island, Canada	0.3366	0.6264	0.3145	0.2882	0.4544	0.2755	0.1817	0.2689	0.1767	0.1261	0.1848	0.1231	0.0685	0.0999	0.0670
Portland, Oregon	0.3573	0.6662	0.3320	0.3051	0.4761	0.2901	0.1908	0.2789	0.1853	0.1320	0.1911	0.1289	0.0716	0.1031	0.0700
Pyrenee Mountains	0.3660	0.6859	0.3432	0.3125	0.4877	0.2989	0.1948	0.2846	0.1901	0.1346	0.1948	0.1320	0.0729	0.1050	0.0717
Quito, Ecuador	0.4748	0.8878	0.4594	0.3969	0.6056	0.3915	0.2419	0.3416	0.2426	0.1656	0.2312	0.1667	0.0891	0.1237	0.0898
Santiago, Chile	0.3769	0.6697	0.3322	0.3139	0.4773	0.2905	0.1930	0.2791	0.1860	0.1330	0.1912	0.1294	0.0720	0.1032	0.0704
Spokane, Washington	0.3336	0.6383	0.3196	0.2890	0.4607	0.2797	0.1834	0.2717	0.1790	0.1274	0.1866	0.1246	0.0693	0.1008	0.0678
Tangmai, Tibet	0.3873	0.7387	0.3789	0.3323	0.5180	0.3274	0.2070	0.2991	0.2061	0.1428	0.2040	0.1426	0.0773	0.1098	0.0772
Tehran, Iran	0.3376	0.6582	0.3274	0.2937	0.4706	0.2864	0.1864	0.2759	0.1831	0.1295	0.1892	0.1275	0.0704	0.1022	0.0693
Tucson, Arizona	0.3677	0.6654	0.3265	0.3084	0.4741	0.2863	0.1907	0.2772	0.1839	0.1315	0.1900	0.1280	0.0712	0.1026	0.0696
Ural Mountains	0.3174	0.6002	0.3061	0.2758	0.4422	0.2680	0.1758	0.2641	0.1715	0.1223	0.1819	0.1194	0.0666	0.0984	0.0649
Xining, China	0.3433	0.6606	0.3311	0.2972	0.4732	0.2893	0.1878	0.2777	0.1843	0.1305	0.1905	0.1282	0.0709	0.1029	0.0697

Appendix G

TIME DELAYS AND ANGLE ERRORS FOR DATABAASES AND SEASONS/ANGLES BY HOURS

Time delays and angle errors are compared for 10 areas of interest based on databases and elevation angles from the horizon to 10° above the horizon by six hourly intervals.

Time Delay (ns) for Selected Areas-of-Interest
ECM, HIRAS, MRF Data for February 1995
(0000, 0600, 1200 and 1800 Hours)

AOI	ECM	HIRAS 0000	HIRAS 0600	HIRAS 1200	HIRAS 1800	MRF (2/15/95) 0000	MRF (2/15/95) 0600	MRF (2/15/95) 1200	MRF (2/15/95) 1800
Elevation Angle = 0°									
(1) Ahaggar, Algeria (AHAGR)	327.341	342.124	347.127	341.886	334.681	233.014	333.977	333.977	333.977
(2) Amazon Forest (AMFOR)	414.599	409.004	419.206	415.577	397.194	284.660	430.332	430.921	425.598
(3) Bangkok, Thailand (BANGK)	420.464	420.108	386.867	410.796	429.896	280.851	415.801	421.908	362.254
(4) Washington, D.C. (DC)	349.221	345.562	352.688	349.972	342.541	235.495	340.299	350.258	342.148
(5) Alaska (NAK)	338.442	336.195	335.800	335.914	335.632	235.790	342.662	341.378	397.285
(6) Northern Australia, Tanami Desert (NAUS)	380.022	374.126	374.585	378.186	380.108	268.152	368.749	382.032	346.790
(7) Pyrenee Mountains (PYRNES)	358.231	356.322	357.972	348.950	350.527	237.449	345.132	345.459	416.228
(8) Spokane, Washington (SPOK)	351.427	342.862	346.061	346.672	344.292	231.449	338.602	334.725	337.097
(9) Tehran, Iran (TEHRAN)	359.556	362.262	359.515	356.345	359.920	249.531	365.635	366.336	365.671
(10) Xining, China (XINING)	351.107	349.813	345.746	347.505	344.073	240.897	339.384	339.867	348.705
Elevation Angle = 1°									
(1) Ahaggar, Algeria (AHAGR)	232.272	237.628	240.150	237.372	233.373	233.014	233.243	226.483	226.665
(2) Amazon Forest (AMFOR)	278.704	275.329	280.539	278.899	269.684	284.660	283.922	283.764	281.350
(3) Bangkok, Thailand (BANGK)	279.963	277.713	261.444	274.019	284.891	280.851	276.481	279.323	251.390
(4) Washington, D.C. (DC)	241.747	240.157	243.271	242.208	238.029	235.495	237.922	244.569	235.207
(5) Alaska (NAK)	235.608	234.476	234.409	234.379	234.339	235.790	235.991	235.002	267.999
(6) Northern Australia, Tanami Desert (NAUS)	263.191	259.393	260.912	262.519	264.340	268.152	255.100	261.378	238.225
(7) Pyrenee Mountains (PYRNES)	246.886	244.743	245.891	241.368	242.380	237.449	237.586	237.710	277.508
(8) Spokane, Washington (SPOK)	243.357	238.974	240.747	240.859	239.466	231.449	234.155	232.070	233.513
(9) Tehran, Iran (TEHRAN)	248.737	248.075	247.153	245.049	246.939	249.531	250.258	251.116	250.591
(10) Xining, China (XINING)	244.011	243.055	240.636	240.870	239.289	240.897	235.567	236.122	241.203
Elevation Angle = 3°									
(1) Ahaggar, Algeria (AHAGR)	134.515	135.614	136.574	135.463	133.745	132.689	132.124	129.977	130.247
(2) Amazon Forest (AMFOR)	153.248	152.046	154.033	153.416	149.956	153.590	153.295	153.142	151.921
(3) Bangkok, Thailand (BANGK)	153.101	151.191	145.154	150.245	154.766	150.865	150.086	150.913	141.381
(4) Washington, D.C. (DC)	136.991	136.462	137.450	137.198	135.409	133.547	135.016	138.436	131.975
(5) Alaska (NAK)	133.283	132.844	132.906	132.843	132.895	132.508	132.518	131.997	147.793
(6) Northern Australia, Tanami Desert (NAUS)	148.312	146.523	147.461	148.062	148.989	146.998	143.067	145.730	133.481
(7) Pyrenee Mountains (PYRNES)	139.083	137.795	138.388	136.636	137.127	133.174	133.270	133.338	150.839
(8) Spokane, Washington (SPOK)	137.606	135.891	136.650	136.611	135.994	130.462	131.520	130.618	131.133
(9) Tehran, Iran (TEHRAN)	140.356	139.391	139.177	138.205	138.960	139.346	139.579	139.913	139.626
(10) Xining, China (XINING)	138.453	137.901	136.799	136.646	136.060	135.493	133.211	133.614	135.804
Elevation Angle = 5°									
(1) Ahaggar, Algeria (AHAGR)	91.309	91.733	92.293	91.637	90.598	89.457	88.979	87.826	88.035
(2) Amazon Forest (AMFOR)	102.433	101.778	102.927	102.570	100.563	101.932	101.756	101.658	100.840
(3) Bangkok, Thailand (BANGK)	102.232	100.891	97.390	100.433	103.126	100.074	99.772	100.199	94.818
(4) Washington, D.C. (DC)	92.382	92.093	92.623	92.516	91.431	89.843	90.837	93.026	88.535
(5) Alaska (NAK)	89.743	89.485	89.543	89.494	89.541	88.922	88.906	88.574	98.666
(6) Northern Australia, Tanami Desert (NAUS)	99.766	98.667	99.264	99.623	100.189	98.019	95.929	97.568	89.495
(7) Pyrenee Mountains (PYRNES)	93.595	92.754	93.137	92.109	92.417	89.305	89.373	89.423	100.292
(8) Spokane, Washington (SPOK)	92.682	91.673	92.136	92.098	91.718	87.543	88.161	87.604	87.891
(9) Tehran, Iran (TEHRAN)	94.485	93.790	93.685	93.090	93.537	93.342	93.453	93.608	93.434
(10) Xining, China (XINING)	93.352	92.987	92.306	92.172	91.830	90.935	89.560	89.846	91.170
Elevation Angle = 10°									
(1) Ahaggar, Algeria (AHAGR)	49.276	49.404	49.676	49.355	48.840	48.010	47.727	47.203	47.322
(2) Amazon Forest (AMFOR)	54.747	54.447	55.000	54.828	53.857	54.179	54.090	54.041	53.605
(3) Bangkok, Thailand (BANGK)	54.613	53.885	52.187	53.693	55.017	53.185	53.087	53.277	50.698
(4) Washington, D.C. (DC)	49.644	49.512	49.752	49.716	49.175	48.138	48.671	49.800	47.355
(5) Alaska (NAK)	48.168	48.044	48.079	48.051	48.080	47.572	47.556	47.384	52.628
(6) Northern Australia, Tanami Desert (NAUS)	53.525	52.975	53.279	53.458	53.738	52.254	51.305	52.132	47.850
(7) Pyrenee Mountains (PYRNES)	50.223	49.785	49.985	49.484	49.640	47.753	47.790	47.818	53.368
(8) Spokane, Washington (SPOK)	49.758	49.265	49.497	49.474	49.282	46.819	47.120	46.837	46.972
(9) Tehran, Iran (TEHRAN)	50.714	50.332	50.287	49.989	50.209	49.882	49.926	49.983	49.898
(10) Xining, China (XINING)	50.152	49.960	49.616	49.536	49.369	48.651	47.971	48.127	48.784

Time Delay (ns) for Selected Areas-of-Interest
ECM, HIRAS and MRF Data for May 1995
(0000, 0600, 1200 and 1800 Hours)

	Elevation Angle = 0°								
	ECM	HIRAS				MRF (5/15/95)			
AOI		0000	0600	1200	1800	0000	0600	1200	1800
(1) Ahaggar, Algeria (AHAGR)	336.942	344.020	347.550	340.229	329.993	333.977	333.977	333.977	333.977
(2) Amazon Forest (AMFOR)	427.698	426.328	436.425	425.004	413.425	444.884	440.500	439.570	441.766
(3) Bangkok, Thailand (BANGK)	432.776	431.326	409.169	429.142	453.463	442.801	448.877	437.902	456.759
(4) Washington, D.C. (DC)	378.583	370.231	393.225	374.390	358.033	411.738	402.308	395.358	384.545
(5) Alaska (NAK)	349.500	347.413	348.213	348.158	348.506	347.539	348.154	347.976	348.359
(6) Northern Australia, Tanami Desert (NAUS)	355.513	358.990	365.309	364.949	368.113	368.313	361.000	372.211	380.715
(7) Pyrenee Mountains (PYRNES)	371.046	371.363	376.097	357.338	358.349	358.113	354.309	351.994	356.325
(8) Spokane, Washington (SPOK)	363.542	339.734	349.061	355.338	339.338	364.513	387.812	366.909	375.653
(9) Tehran, Iran (TEHRAN)	371.319	384.819	383.658	380.822	378.412	378.173	368.786	362.798	376.777
(10) Xining, China (XINING)	391.011	376.755	370.322	373.471	366.369	358.671	324.982	343.065	370.583
	Elevation Angle = 1°								
	ECM	HIRAS				MRF (5/15/95)			
		0000	0600	1200	1800	0000	0600	1200	1800
(1) Ahaggar, Algeria (AHAGR)	238.027	239.720	241.890	238.245	232.711	221.696	223.921	217.981	216.565
(2) Amazon Forest (AMFOR)	286.020	285.531	290.823	285.050	279.157	291.633	289.986	288.792	289.884
(3) Bangkok, Thailand (BANGK)	288.709	288.882	277.829	288.049	301.216	291.259	291.367	287.294	296.109
(4) Washington, D.C. (DC)	258.064	254.446	265.852	256.291	247.160	270.271	265.163	262.122	257.838
(5) Alaska (NAK)	241.953	240.914	241.539	241.267	241.635	239.110	239.469	239.458	239.812
(6) Northern Australia, Tanami Desert (NAUS)	248.008	248.504	251.695	251.589	253.244	255.360	252.111	258.086	261.562
(7) Pyrenee Mountains (PYRNES)	254.628	253.025	255.795	246.396	247.238	245.093	243.273	242.125	244.298
(8) Spokane, Washington (SPOK)	249.902	238.784	243.662	246.255	237.555	249.862	262.209	251.304	254.905
(9) Tehran, Iran (TEHRAN)	255.922	259.192	259.080	255.672	256.473	258.344	253.846	251.634	258.419
(10) Xining, China (XINING)	267.356	258.318	254.788	254.838	252.356	246.537	228.210	238.949	253.179
	Elevation Angle = 3°								
	ECM	HIRAS				MRF (5/15/95)			
		0000	0600	1200	1800	0000	0600	1200	1800
(1) Ahaggar, Algeria (AHAGR)	137.458	137.204	138.142	136.847	134.529	128.373	129.123	127.132	126.550
(2) Amazon Forest (AMFOR)	156.544	156.609	158.669	156.443	154.207	156.549	156.171	155.550	155.821
(3) Bangkok, Thailand (BANGK)	157.617	157.948	153.844	157.746	162.934	156.600	155.601	154.408	157.667
(4) Washington, D.C. (DC)	144.132	142.968	147.203	143.588	139.805	146.182	144.062	143.231	141.686
(5) Alaska (NAK)	136.782	136.371	136.735	136.507	136.760	134.028	134.204	134.270	134.467
(6) Northern Australia, Tanami Desert (NAUS)	141.112	140.718	141.909	141.916	142.543	143.652	142.485	144.979	145.903
(7) Pyrenee Mountains (PYRNES)	142.691	141.504	142.678	139.130	139.549	136.975	136.304	135.905	136.719
(8) Spokane, Washington (SPOK)	140.479	136.750	138.648	139.395	135.843	139.295	144.208	139.877	140.693
(9) Tehran, Iran (TEHRAN)	144.205	144.130	144.163	142.372	143.224	143.572	141.900	141.627	143.904
(10) Xining, China (XINING)	149.260	144.929	143.432	142.919	142.337	138.063	130.639	135.437	140.879
	Elevation Angle = 5°								
	ECM	HIRAS				MRF (5/15/95)			
		0000	0600	1200	1800	0000	0600	1200	1800
(1) Ahaggar, Algeria (AHAGR)	93.236	92.881	93.445	92.719	91.332	87.038	87.439	86.355	86.011
(2) Amazon Forest (AMFOR)	104.485	104.589	105.787	104.491	103.188	103.736	103.559	103.181	103.296
(3) Bangkok, Thailand (BANGK)	105.121	105.352	102.972	105.257	108.291	103.811	103.038	102.398	104.293
(4) Washington, D.C. (DC)	96.806	96.172	98.606	96.520	94.263	97.180	95.898	95.477	94.569
(5) Alaska (NAK)	92.132	91.891	92.133	91.973	92.148	89.861	89.976	90.035	90.161
(6) Northern Australia, Tanami Desert (NAUS)	95.271	94.922	95.601	95.621	95.973	96.377	95.694	97.199	97.646
(7) Pyrenee Mountains (PYRNES)	95.873	95.084	95.793	93.737	93.998	91.806	91.418	91.200	91.669
(8) Spokane, Washington (SPOK)	94.492	92.448	93.558	93.943	91.836	93.266	96.158	93.590	93.923
(9) Tehran, Iran (TEHRAN)	97.072	96.774	96.799	95.680	96.264	96.003	95.040	95.018	96.268
(10) Xining, China (XINING)	100.149	97.444	96.537	96.141	95.867	92.590	88.208	91.150	94.295
	Elevation Angle = 10°								
	ECM	HIRAS				MRF (5/15/95)			
		0000	0600	1200	1800	0000	0600	1200	1800
(1) Ahaggar, Algeria (AHAGR)	50.293	50.047	50.328	49.985	49.302	46.885	47.065	46.568	46.401
(2) Amazon Forest (AMFOR)	55.791	55.865	56.444	55.817	55.184	55.084	55.011	54.824	54.865
(3) Bangkok, Thailand (BANGK)	56.104	56.228	55.072	56.189	57.663	55.137	54.700	54.408	55.327
(4) Washington, D.C. (DC)	51.897	51.606	52.774	51.771	50.659	51.716	51.075	50.889	50.444
(5) Alaska (NAK)	49.470	49.354	49.482	49.395	49.490	48.047	48.107	48.144	48.208
(6) Northern Australia, Tanami Desert (NAUS)	51.240	51.032	51.355	51.371	51.534	51.554	51.219	51.968	52.153
(7) Pyrenee Mountains (PYRNES)	51.400	50.987	51.341	50.348	50.480	49.085	48.898	48.797	49.023
(8) Spokane, Washington (SPOK)	50.698	49.753	50.292	50.463	49.429	49.834	51.246	49.982	50.093
(9) Tehran, Iran (TEHRAN)	52.109	51.881	51.894	51.327	51.638	51.249	50.787	50.824	51.404
(10) Xining, China (XINING)	53.644	52.272	51.819	51.595	51.482	49.526	47.385	48.862	50.378

Time Delay (ns) for Selected Areas-of-Interest
ECM, HIRAS and MRF Data for August 1995
(0000, 0600, 1200 and 1800 Hours)

AOI	ECM	HIRAS 0000	HIRAS 0600	HIRAS 1200	HIRAS 1800	MRF (8/15/95) 0000	MRF (8/15/95) 0600	MRF (8/15/95) 1200	MRF (8/15/95) 1800
Elevation Angle = 0°									
(1) Ahaggar, Algeria (AHAGR)	352.643	340.933	347.865	335.466	318.674	333.977	333.977	333.977	333.977
(2) Amazon Forest (AMFOR)	428.918	428.283	439.117	424.684	410.052	423.393	423.941	423.917	416.684
(3) Bangkok, Thailand (BANGK)	426.827	425.203	414.481	427.114	447.782	449.259	446.303	443.680	454.716
(4) Washington, D.C. (DC)	415.545	405.406	439.642	407.114	385.754	444.409	444.876	439.703	432.442
(5) Alaska (NAK)	365.027	367.345	370.983	368.255	370.776	364.743	366.320	364.661	365.739
(6) Northern Australia, Tanami Desert (NAUS)	345.607	352.018	358.868	359.280	362.959	336.698	322.726	332.226	338.349
(7) Pyrenee Mountains (PYRNES)	396.137	398.836	405.959	375.807	377.553	376.799	373.338	371.243	374.658
(8) Spokane, Washington (SPOK)	367.443	349.225	359.091	367.217	346.217	359.802	368.629	367.837	373.143
(9) Tehran, Iran (TEHRAN)	340.393	410.900	411.677	411.906	402.988	363.152	338.510	295.937	317.683
(10) Xining, China (XINING)	401.505	406.601	410.661	416.224	398.841	450.467	462.384	440.911	418.132
Elevation Angle = 1°									
(1) Ahaggar, Algeria (AHAGR)	246.727	239.081	242.624	236.430	227.049	229.765	233.276	226.036	220.845
(2) Amazon Forest (AMFOR)	285.843	286.097	291.846	284.246	276.972	278.708	278.578	278.314	276.002
(3) Bangkok, Thailand (BANGK)	285.733	286.319	280.663	288.012	298.596	296.381	294.419	293.125	297.168
(4) Washington, D.C. (DC)	278.184	274.224	291.383	274.830	263.358	287.927	288.244	286.110	282.132
(5) Alaska (NAK)	252.455	253.041	255.238	253.510	255.018	249.497	250.638	249.368	250.028
(6) Northern Australia, Tanami Desert (NAUS)	242.222	244.144	247.439	247.623	249.701	233.926	227.801	232.144	234.744
(7) Pyrenee Mountains (PYRNES)	268.626	265.906	270.449	255.096	256.533	256.037	254.482	253.640	254.876
(8) Spokane, Washington (SPOK)	252.852	244.372	249.709	253.029	241.510	248.549	252.404	251.673	254.407
(9) Tehran, Iran (TEHRAN)	240.367	271.821	272.990	270.255	269.192	250.902	237.675	215.575	227.449
(10) Xining, China (XINING)	276.256	277.087	278.976	279.438	271.937	297.691	304.168	292.591	279.092
Elevation Angle = 3°									
(1) Ahaggar, Algeria (AHAGR)	141.051	137.458	138.757	136.520	132.477	132.047	133.178	130.904	128.760
(2) Amazon Forest (AMFOR)	156.183	156.587	158.833	155.865	153.126	150.732	150.568	150.397	149.847
(3) Bangkok, Thailand (BANGK)	156.593	157.294	155.070	158.173	162.130	159.816	158.835	158.454	159.521
(4) Washington, D.C. (DC)	152.795	151.634	158.062	151.761	147.206	153.796	153.962	153.189	151.397
(5) Alaska (NAK)	142.337	142.360	143.392	142.566	143.277	139.499	140.039	139.347	139.562
(6) Northern Australia, Tanami Desert (NAUS)	138.605	138.766	139.926	139.990	140.829	132.639	130.695	132.237	132.966
(7) Pyrenee Mountains (PYRNES)	149.054	146.552	148.572	142.695	143.331	142.250	141.686	141.445	141.733
(8) Spokane, Washington (SPOK)	142.439	139.598	141.714	142.666	137.901	139.587	140.507	140.042	140.817
(9) Tehran, Iran (TEHRAN)	138.557	149.003	149.568	147.819	148.311	140.960	135.749	127.461	132.384
(10) Xining, China (XINING)	154.568	153.832	154.427	153.744	151.390	160.326	162.816	157.975	151.845
Elevation Angle = 5°									
(1) Ahaggar, Algeria (AHAGR)	95.389	93.166	93.903	92.637	90.198	89.302	89.911	88.720	87.438
(2) Amazon Forest (AMFOR)	104.216	104.518	105.828	104.095	102.500	100.158	100.038	99.930	99.655
(3) Bangkok, Thailand (BANGK)	104.553	105.045	103.725	105.596	107.870	105.957	105.338	105.140	105.681
(4) Washington, D.C. (DC)	102.141	101.523	105.240	101.579	98.894	101.893	101.993	101.542	100.438
(5) Alaska (NAK)	95.802	95.779	96.426	95.908	96.355	93.531	93.860	93.414	93.522
(6) Northern Australia, Tanami Desert (NAUS)	93.759	93.734	94.381	94.421	94.905	89.376	88.322	89.212	89.572
(7) Pyrenee Mountains (PYRNES)	99.898	98.170	99.403	95.979	96.354	95.217	94.890	94.767	94.899
(8) Spokane, Washington (SPOK)	95.902	94.344	95.584	96.076	93.235	93.628	94.011	93.696	94.062
(9) Tehran, Iran (TEHRAN)	93.932	99.699	100.033	98.905	99.333	94.632	91.589	86.884	89.806
(10) Xining, China (XINING)	103.699	103.038	103.350	102.793	101.517	106.254	107.695	104.763	100.986
Elevation Angle = 10°									
(1) Ahaggar, Algeria (AHAGR)	51.362	50.241	50.591	49.991	48.783	48.028	48.305	47.778	47.146
(2) Amazon Forest (AMFOR)	55.641	55.811	56.446	55.605	54.830	53.282	53.214	53.160	53.040
(3) Bangkok, Thailand (BANGK)	55.839	56.104	55.452	56.384	57.474	56.268	55.953	55.863	56.101
(4) Washington, D.C. (DC)	54.601	54.321	56.113	54.342	53.029	54.117	54.165	53.946	53.390
(5) Alaska (NAK)	51.422	51.400	51.730	51.466	51.694	50.023	50.187	49.956	50.001
(6) Northern Australia, Tanami Desert (NAUS)	50.492	50.441	50.742	50.764	50.995	47.965	47.481	47.912	48.063
(7) Pyrenee Mountains (PYRNES)	53.483	52.557	53.175	51.514	51.697	50.878	50.718	50.665	50.717
(8) Spokane, Washington (SPOK)	51.492	50.772	51.375	51.593	50.195	50.079	50.208	50.040	50.186
(9) Tehran, Iran (TEHRAN)	50.659	53.348	53.511	52.929	53.181	50.660	49.185	46.955	48.385
(10) Xining, China (XINING)	55.534	55.136	55.275	54.953	54.364	56.414	57.111	55.648	53.744

Time Delay (ns) for Selected Areas-of-Interest
ECM, HIRAS and MRF Data for November 1995
(0000, 0600, 1200 and 1800 Hours)

AOI	ECM	HIRAS 0000	HIRAS 0600	HIRAS 1200	HIRAS 1800	MRF (11/15/95) 0000	MRF (11/15/95) 0600	MRF (11/15/95) 1200	MRF (11/15/95) 1800
Elevation Angle = 0°									
(1) Ahaggar, Algeria (AHAGR)	339.743	353.838	361.438	348.316	348.316	333.977	333.977	333.977	333.977
(2) Amazon Forest (AMFOR)	429.415	427.291	440.174	410.123	410.123	429.167	425.660	427.750	419.361
(3) Bangkok, Thailand (BANGK)	426.611	412.367	389.367	422.780	422.780	429.860	429.100	427.895	425.650
(4) Washington, D.C. (DC)	363.730	357.936	368.886	348.946	348.946	344.772	338.922	337.303	335.418
(5) Alaska (NAK)	344.556	339.813	339.344	339.373	339.373	336.907	337.268	337.500	338.061
(6) Northern Australia, Tanami Desert (NAUS)	363.967	366.365	369.099	373.619	373.619	386.004	374.991	388.294	396.555
(7) Pyrenee Mountains (PYRNES)	367.439	365.555	368.677	366.292	366.292	349.250	348.060	348.461	349.215
(8) Spokane, Washington (SPOK)	353.650	347.716	349.509	347.426	347.426	374.254	370.951	364.239	365.506
(9) Tehran, Iran (TEHRAN)	361.543	379.544	377.789	379.579	379.579	320.792	318.316	313.766	320.485
(10) Xining, China (XINING)	362.582	357.677	359.584	358.526	358.526	345.041	327.513	332.144	339.207
Elevation Angle = 1°									
(1) Ahaggar, Algeria (AHAGR)	239.439	244.867	248.616	241.693	241.693	232.926	234.026	225.915	226.020
(2) Amazon Forest (AMFOR)	286.665	286.020	292.742	277.440	277.440	285.469	283.607	284.949	281.669
(3) Bangkok, Thailand (BANGK)	286.252	278.904	266.930	286.202	286.202	288.893	287.055	287.325	286.163
(4) Washington, D.C. (DC)	249.291	246.594	251.622	241.210	241.210	238.511	234.849	233.738	232.558
(5) Alaska (NAK)	238.663	236.462	236.357	236.390	236.390	233.122	233.745	233.420	233.823
(6) Northern Australia, Tanami Desert (NAUS)	254.270	254.340	256.479	258.922	258.922	265.251	260.223	265.776	268.790
(7) Pyrenee Mountains (PYRNES)	252.125	250.162	251.957	250.869	250.869	240.729	240.299	240.383	240.669
(8) Spokane, Washington (SPOK)	244.625	241.673	242.680	241.316	241.316	255.213	253.013	248.830	249.462
(9) Tehran, Iran (TEHRAN)	250.494	256.589	256.271	256.988	256.988	226.976	225.913	223.343	226.039
(10) Xining, China (XINING)	250.770	247.653	248.149	246.903	246.903	239.398	229.491	231.955	235.810
Elevation Angle = 3°									
(1) Ahaggar, Algeria (AHAGR)	137.818	139.053	140.440	137.645	137.645	132.625	133.031	130.110	130.043
(2) Amazon Forest (AMFOR)	156.612	156.804	159.403	153.552	153.552	154.575	153.843	154.578	153.546
(3) Bangkok, Thailand (BANGK)	156.824	153.795	149.171	157.357	157.357	157.396	156.209	156.569	156.095
(4) Washington, D.C. (DC)	140.228	139.262	140.985	136.891	136.891	133.944	132.103	131.643	131.177
(5) Alaska (NAK)	134.715	133.958	134.002	134.032	134.032	131.193	131.633	131.426	131.679
(6) Northern Australia, Tanami Desert (NAUS)	144.573	144.100	145.077	146.048	146.048	147.839	146.040	147.801	148.367
(7) Pyrenee Mountains (PYRNES)	141.504	140.354	141.150	140.760	140.760	135.140	135.027	134.994	135.047
(8) Spokane, Washington (SPOK)	138.195	137.075	137.515	136.867	136.867	141.746	140.508	138.440	138.701
(9) Tehran, Iran (TEHRAN)	141.694	142.922	142.921	143.175	143.175	130.767	130.429	129.304	129.932
(10) Xining, China (XINING)	141.610	140.097	140.035	139.270	139.270	135.242	131.144	132.079	133.552
Elevation Angle = 5°									
(1) Ahaggar, Algeria (AHAGR)	93.371	93.895	94.692	93.034	93.034	89.425	89.660	88.007	87.959
(2) Amazon Forest (AMFOR)	104.481	104.698	106.211	102.803	102.803	102.619	102.185	102.669	102.093
(3) Bangkok, Thailand (BANGK)	104.673	102.838	100.131	105.052	105.052	104.578	103.799	104.047	103.763
(4) Washington, D.C. (DC)	94.410	93.861	94.818	92.420	92.420	89.817	88.627	88.365	88.113
(5) Alaska (NAK)	90.673	90.252	90.299	90.320	90.320	88.044	88.350	88.229	88.415
(6) Northern Australia, Tanami Desert (NAUS)	97.517	97.146	97.727	98.294	98.294	98.888	97.856	98.823	99.024
(7) Pyrenee Mountains (PYRNES)	95.140	94.392	94.882	94.656	94.656	90.660	90.599	90.565	90.582
(8) Spokane, Washington (SPOK)	93.060	92.409	92.679	92.275	92.275	94.786	93.969	92.662	92.813
(9) Tehran, Iran (TEHRAN)	95.478	95.978	95.992	96.141	96.141	88.440	88.258	87.575	87.852
(10) Xining, China (XINING)	95.361	94.411	94.318	93.815	93.815	90.916	88.477	89.013	89.858
Elevation Angle = 10°									
(1) Ahaggar, Algeria (AHAGR)	50.326	50.510	50.893	50.080	50.080	48.000	48.113	47.331	47.306
(2) Amazon Forest (AMFOR)	55.773	55.916	56.647	54.994	54.994	54.547	54.333	54.588	54.316
(3) Bangkok, Thailand (BANGK)	55.889	54.973	53.653	56.090	56.090	55.603	55.196	55.327	55.187
(4) Washington, D.C. (DC)	50.690	50.429	50.876	49.710	49.710	48.026	47.405	47.281	47.169
(5) Alaska (NAK)	48.659	48.463	48.493	48.505	48.505	47.100	47.267	47.211	47.317
(6) Northern Australia, Tanami Desert (NAUS)	52.408	52.198	52.481	52.755	52.755	52.795	52.300	52.751	52.804
(7) Pyrenee Mountains (PYRNES)	51.027	50.639	50.886	50.777	50.777	48.493	48.465	48.444	48.447
(8) Spokane, Washington (SPOK)	49.956	49.642	49.777	49.573	49.573	50.599	50.171	49.501	49.573
(9) Tehran, Iran (TEHRAN)	51.281	51.451	51.462	51.535	51.535	47.552	47.470	47.130	47.235
(10) Xining, China (XINING)	51.195	50.711	50.645	50.382	50.382	48.695	47.497	47.752	48.157

Angle Error (degrees) for Selected Areas-of-Interest
ECM, HIRAS and MRF Data for February 1995
(0000, 0600, 1200 and 1800 Hours)

AOI	ECM	HIRAS 0000	HIRAS 0600	HIRAS 1200	HIRAS 1800	MRF (2/15/95) 0000	MRF (2/15/95) 0600	MRF (2/15/95) 1200	MRF (2/15/95) 1800
Elevation Angle = 0°									
(1) Ahaggar, Algeria (AHAGR)	0.2550	0.3256	0.3389	0.3267	0.3117	0.2701	0.2912	0.2346	0.2362
(2) Amazon Forest (AMFOR)	0.4521	0.4466	0.4687	0.4584	0.4152	0.4807	0.4786	0.4852	0.4867
(3) Bangkok, Thailand (BANGK)	0.4827	0.5017	0.4211	0.4713	0.4999	0.5054	0.4467	0.4617	0.4684
(4) Washington, D.C. (DC)	0.3325	0.3189	0.3443	0.3335	0.3188	0.2672	0.2660	0.2734	0.2960
(5) Alaska (NAK)	0.3000	0.2933	0.2906	0.2920	0.2901	0.3048	0.3061	0.3072	0.3113
(6) Northern Australia, Tanami Desert (NAUS)	0.3456	0.3404	0.3244	0.3373	0.3310	0.4198	0.3078	0.3496	0.3978
(7) Pyrenee Mountains (PYRNES)	0.3477	0.3578	0.3584	0.3338	0.3354	0.3096	0.3089	0.3107	0.3163
(8) Spokane, Washington (SPOK)	0.3295	0.3067	0.3137	0.3180	0.3139	0.2731	0.2875	0.2768	0.2788
(9) Tehran, Iran (TEHRAN)	0.3371	0.3706	0.3573	0.3558	0.3639	0.3372	0.3385	0.3309	0.3324
(10) Xining, China (XINING)	0.3209	0.3215	0.3149	0.3288	0.3169	0.3003	0.2857	0.2842	0.3007
Elevation Angle = 1°									
(1) Ahaggar, Algeria (AHAGR)	0.2299	0.2749	0.2849	0.2754	0.2640	0.2376	0.2528	0.2141	0.2122
(2) Amazon Forest (AMFOR)	0.3796	0.3700	0.3864	0.3806	0.3488	0.3939	0.3918	0.3944	0.3965
(3) Bangkok, Thailand (BANGK)	0.3972	0.4087	0.3508	0.3880	0.4133	0.4055	0.3723	0.3853	0.3878
(4) Washington, D.C. (DC)	0.2850	0.2765	0.2933	0.2862	0.2743	0.2402	0.2398	0.2464	0.2648
(5) Alaska (NAK)	0.2730	0.2683	0.2663	0.2673	0.2658	0.2623	0.2638	0.2635	0.2662
(6) Northern Australia, Tanami Desert (NAUS)	0.3059	0.3003	0.2950	0.3026	0.3019	0.3476	0.2773	0.2990	0.3312
(7) Pyrenee Mountains (PYRNES)	0.2987	0.3023	0.3035	0.2863	0.2878	0.2665	0.2662	0.2670	0.2704
(8) Spokane, Washington (SPOK)	0.2858	0.2693	0.2747	0.2773	0.2736	0.2430	0.2532	0.2460	0.2514
(9) Tehran, Iran (TEHRAN)	0.2945	0.3109	0.3032	0.3000	0.3063	0.2875	0.2895	0.2875	0.2885
(10) Xining, China (XINING)	0.2794	0.2797	0.2742	0.2818	0.2744	0.2631	0.2486	0.2476	0.2614
Elevation Angle = 3°									
(1) Ahaggar, Algeria (AHAGR)	0.1526	0.1725	0.1776	0.1726	0.1664	0.1506	0.1573	0.1393	0.1378
(2) Amazon Forest (AMFOR)	0.2312	0.2252	0.2337	0.2310	0.2149	0.2322	0.2310	0.2316	0.2329
(3) Bangkok, Thailand (BANGK)	0.2382	0.2421	0.2134	0.2326	0.2471	0.2355	0.2220	0.2286	0.2298
(4) Washington, D.C. (DC)	0.1797	0.1759	0.1837	0.1804	0.1739	0.1537	0.1540	0.1588	0.1691
(5) Alaska (NAK)	0.1763	0.1741	0.1732	0.1736	0.1729	0.1639	0.1648	0.1642	0.1653
(6) Northern Australia, Tanami Desert (NAUS)	0.1966	0.1926	0.1920	0.1954	0.1964	0.2085	0.1766	0.1862	0.2013
(7) Pyrenee Mountains (PYRNES)	0.1876	0.1879	0.1888	0.1803	0.1813	0.1660	0.1659	0.1661	0.1676
(8) Spokane, Washington (SPOK)	0.1815	0.1732	0.1760	0.1771	0.1750	0.1558	0.1608	0.1575	0.1608
(9) Tehran, Iran (TEHRAN)	0.1871	0.1923	0.1892	0.1868	0.1901	0.1775	0.1789	0.1797	0.1796
(10) Xining, China (XINING)	0.1786	0.1783	0.1751	0.1780	0.1746	0.1649	0.1573	0.1567	0.1640
Elevation Angle = 5°									
(1) Ahaggar, Algeria (AHAGR)	0.1077	0.1198	0.1231	0.1198	0.1158	0.1042	0.1082	0.0969	0.0961
(2) Amazon Forest (AMFOR)	0.1582	0.1542	0.1597	0.1580	0.1478	0.1566	0.1558	0.1561	0.1569
(3) Bangkok, Thailand (BANGK)	0.1622	0.1643	0.1461	0.1584	0.1680	0.1582	0.1501	0.1542	0.1551
(4) Washington, D.C. (DC)	0.1248	0.1224	0.1273	0.1252	0.1210	0.1065	0.1068	0.1103	0.1170
(5) Alaska (NAK)	0.1229	0.1215	0.1209	0.1212	0.1208	0.1128	0.1134	0.1129	0.1136
(6) Northern Australia, Tanami Desert (NAUS)	0.1366	0.1339	0.1338	0.1359	0.1368	0.1413	0.1217	0.1277	0.1371
(7) Pyrenee Mountains (PYRNES)	0.1300	0.1299	0.1305	0.1251	0.1258	0.1142	0.1141	0.1142	0.1151
(8) Spokane, Washington (SPOK)	0.1262	0.1209	0.1228	0.1234	0.1220	0.1079	0.1112	0.1090	0.1111
(9) Tehran, Iran (TEHRAN)	0.1299	0.1327	0.1309	0.1292	0.1314	0.1217	0.1227	0.1235	0.1233
(10) Xining, China (XINING)	0.1245	0.1242	0.1221	0.1237	0.1216	0.1136	0.1087	0.1083	0.1131
Elevation Angle = 10°									
(1) Ahaggar, Algeria (AHAGR)	0.0592	0.0652	0.0668	0.0652	0.0631	0.0564	0.0583	0.0527	0.0522
(2) Amazon Forest (AMFOR)	0.0851	0.0830	0.0858	0.0850	0.0798	0.0832	0.0828	0.0830	0.0834
(3) Bangkok, Thailand (BANGK)	0.0870	0.0879	0.0787	0.0850	0.0899	0.0839	0.0799	0.0820	0.0825
(4) Washington, D.C. (DC)	0.0678	0.0666	0.0691	0.0681	0.0659	0.0577	0.0579	0.0598	0.0632
(5) Alaska (NAK)	0.0669	0.0662	0.0659	0.0660	0.0658	0.0608	0.0611	0.0609	0.0612
(6) Northern Australia, Tanami Desert (NAUS)	0.0742	0.0728	0.0728	0.0738	0.0744	0.0754	0.0656	0.0687	0.0734
(7) Pyrenee Mountains (PYRNES)	0.0706	0.0704	0.0708	0.0680	0.0684	0.0615	0.0615	0.0616	0.0620
(8) Spokane, Washington (SPOK)	0.0686	0.0659	0.0669	0.0672	0.0665	0.0584	0.0601	0.0590	0.0601
(9) Tehran, Iran (TEHRAN)	0.0706	0.0719	0.0710	0.0701	0.0712	0.0655	0.0660	0.0664	0.0663
(10) Xining, China (XINING)	0.0678	0.0676	0.0665	0.0673	0.0663	0.0613	0.0588	0.0586	0.0611

Angle Error (degrees) for Selected Areas-of-Interest
ECM, HIRAS and MRF Data for May 1995
(0000, 0600, 1200 and 1800)

AOI	ECM	HIRAS 0000	HIRAS 0600	HIRAS 1200	HIRAS 1800	MRF (5/15/95) 0000	MRF (5/15/95) 0600	MRF (5/15/95) 1200	MRF (5/15/95) 1800
Elevation Angle = 0°									
(1) Ahaggar, Algeria (AHAGR)	0.2746	0.3185	0.3224	0.3025	0.2783	0.2334	0.2478	0.2478	0.1940
(2) Amazon Forest (AMFOR)	0.4763	0.4719	0.4918	0.4668	0.4410	0.5059	0.4913	0.4976	0.5010
(3) Bangkok, Thailand (BANGK)	0.4853	0.4721	0.4196	0.4645	0.5083	0.4953	0.5355	0.5355	0.5437
(4) Washington, D.C. (DC)	0.3935	0.3649	0.4238	0.3788	0.3480	0.4817	0.4650	0.4650	0.4073
(5) Alaska (NAK)	0.3283	0.3223	0.3220	0.3247	0.3236	0.3124	0.3137	0.3137	0.3116
(6) Northern Australia, Tanami Desert (NAUS)	0.3153	0.3405	0.3568	0.3551	0.3623	0.3042	0.2765	0.2765	0.3363
(7) Pyrenee Mountains (PYRNES)	0.3672	0.3902	0.3973	0.3489	0.3471	0.3358	0.3246	0.3246	0.3299
(8) Spokane, Washington (SPOK)	0.3590	0.2834	0.3072	0.3319	0.2965	0.3315	0.3815	0.3815	0.3634
(9) Tehran, Iran (TEHRAN)	0.3587	0.4340	0.4253	0.4428	0.4126	0.3500	0.3226	0.3226	0.3370
(10) Xining, China (XINING)	0.3910	0.3761	0.3629	0.3901	0.3582	0.3243	0.2506	0.2506	0.3457
Elevation Angle = 1°									
(1) Ahaggar, Algeria (AHAGR)	0.2427	0.2700	0.2750	0.2593	0.2416	0.2024	0.2129	0.2129	0.1756
(2) Amazon Forest (AMFOR)	0.3964	0.3916	0.4067	0.3892	0.3698	0.4108	0.4010	0.4024	0.4069
(3) Bangkok, Thailand (BANGK)	0.4040	0.3977	0.3590	0.3928	0.4283	0.4067	0.4277	0.4277	0.4359
(4) Washington, D.C. (DC)	0.3319	0.3133	0.3557	0.3225	0.2965	0.3853	0.3719	0.3719	0.3365
(5) Alaska (NAK)	0.2857	0.2818	0.2818	0.2834	0.2827	0.2695	0.2704	0.2704	0.2691
(6) Northern Australia, Tanami Desert (NAUS)	0.2792	0.2948	0.3068	0.3057	0.3111	0.2696	0.2527	0.2527	0.2934
(7) Pyrenee Mountains (PYRNES)	0.3163	0.3258	0.3329	0.2977	0.2980	0.2851	0.2776	0.2776	0.2813
(8) Spokane, Washington (SPOK)	0.3076	0.2536	0.2720	0.2882	0.2603	0.2901	0.3281	0.3281	0.3147
(9) Tehran, Iran (TEHRAN)	0.3080	0.3512	0.3478	0.3503	0.3378	0.3015	0.2836	0.2836	0.2950
(10) Xining, China (XINING)	0.3338	0.3201	0.3101	0.3239	0.3051	0.2808	0.2230	0.2230	0.2987
Elevation Angle = 3°									
(1) Ahaggar, Algeria (AHAGR)	0.1595	0.1712	0.1744	0.1663	0.1569	0.1302	0.1355	0.1355	0.1174
(2) Amazon Forest (AMFOR)	0.2402	0.2376	0.2456	0.2367	0.2268	0.2411	0.2366	0.2362	0.2389
(3) Bangkok, Thailand (BANGK)	0.2443	0.2424	0.2231	0.2403	0.2595	0.2395	0.2470	0.2470	0.2521
(4) Washington, D.C. (DC)	0.2049	0.1964	0.2177	0.2006	0.1862	0.2239	0.2167	0.2167	0.2009
(5) Alaska (NAK)	0.1821	0.1802	0.1804	0.1810	0.1807	0.1683	0.1687	0.1687	0.1682
(6) Northern Australia, Tanami Desert (NAUS)	0.1797	0.1860	0.1921	0.1916	0.1945	0.1724	0.1652	0.1652	0.1845
(7) Pyrenee Mountains (PYRNES)	0.1984	0.2006	0.2048	0.1870	0.1877	0.1758	0.1722	0.1722	0.1739
(8) Spokane, Washington (SPOK)	0.1929	0.1667	0.1763	0.1836	0.1686	0.1806	0.2006	0.2006	0.1933
(9) Tehran, Iran (TEHRAN)	0.1941	0.2114	0.2105	0.2088	0.2054	0.1873	0.1789	0.1789	0.1851
(10) Xining, China (XINING)	0.2089	0.2000	0.1947	0.1995	0.1916	0.1745	0.1436	0.1436	0.1847
Elevation Angle = 5°									
(1) Ahaggar, Algeria (AHAGR)	0.1122	0.1193	0.1214	0.1162	0.1101	0.0909	0.0942	0.0942	0.0828
(2) Amazon Forest (AMFOR)	0.1641	0.1625	0.1677	0.1620	0.1557	0.1624	0.1597	0.1592	0.1610
(3) Bangkok, Thailand (BANGK)	0.1667	0.1657	0.1535	0.1644	0.1768	0.1614	0.1657	0.1657	0.1690
(4) Washington, D.C. (DC)	0.1411	0.1359	0.1494	0.1385	0.1291	0.1506	0.1460	0.1460	0.1362
(5) Alaska (NAK)	0.1266	0.1254	0.1256	0.1259	0.1258	0.1158	0.1161	0.1161	0.1158
(6) Northern Australia, Tanami Desert (NAUS)	0.1253	0.1289	0.1329	0.1325	0.1344	0.1192	0.1148	0.1148	0.1269
(7) Pyrenee Mountains (PYRNES)	0.1372	0.1383	0.1409	0.1296	0.1302	0.1205	0.1182	0.1182	0.1193
(8) Spokane, Washington (SPOK)	0.1336	0.1171	0.1232	0.1277	0.1180	0.1238	0.1367	0.1367	0.1319
(9) Tehran, Iran (TEHRAN)	0.1346	0.1448	0.1443	0.1428	0.1410	0.1284	0.1231	0.1231	0.1272
(10) Xining, China (XINING)	0.1444	0.1382	0.1348	0.1375	0.1327	0.1198	0.0997	0.0997	0.1263
Elevation Angle = 10°									
(1) Ahaggar, Algeria (AHAGR)	0.0616	0.0650	0.0661	0.0635	0.0604	0.0495	0.0512	0.0512	0.0454
(2) Amazon Forest (AMFOR)	0.0882	0.0874	0.0901	0.0871	0.0839	0.0863	0.0849	0.0846	0.0855
(3) Bangkok, Thailand (BANGK)	0.0895	0.0890	0.0828	0.0884	0.0948	0.0858	0.0878	0.0878	0.0896
(4) Washington, D.C. (DC)	0.0763	0.0736	0.0805	0.0749	0.0701	0.0800	0.0776	0.0776	0.0727
(5) Alaska (NAK)	0.0689	0.0683	0.0684	0.0685	0.0685	0.0625	0.0626	0.0626	0.0625
(6) Northern Australia, Tanami Desert (NAUS)	0.0682	0.0700	0.0720	0.0719	0.0728	0.0644	0.0622	0.0622	0.0684
(7) Pyrenee Mountains (PYRNES)	0.0744	0.0748	0.0762	0.0704	0.0707	0.0648	0.0636	0.0636	0.0642
(8) Spokane, Washington (SPOK)	0.0724	0.0641	0.0672	0.0695	0.0645	0.0665	0.0732	0.0732	0.0706
(9) Tehran, Iran (TEHRAN)	0.0730	0.0780	0.0778	0.0769	0.0761	0.0690	0.0663	0.0663	0.0684
(10) Xining, China (XINING)	0.0782	0.0749	0.0731	0.0744	0.0720	0.0645	0.0541	0.0541	0.0678

Angle Error (degrees) for Selected Areas-of-Interest
ECM, HIRAS and MRF Data for August 1995
(0000, 0600, 1200 and 1800 Hours)

AOI	ECM	HIRAS 0000	HIRAS 0600	HIRAS 1200	HIRAS 1800	MRF (8/15/95) 0000	MRF (8/15/95) 0600	MRF (8/15/95) 1200	MRF (8/15/95) 1800
Elevation Angle = 0°									
(1) Ahaggar, Algeria (AHAGR)	0.3085	0.2999	0.3175	0.2832	0.2464	0.2542	0.2851	0.2288	0.1994
(2) Amazon Forest (AMFOR)	0.4876	0.4805	0.5009	0.4729	0.4384	0.4824	0.4875	0.4904	0.4604
(3) Bangkok, Thailand (BANGK)	0.4727	0.4539	0.4315	0.4504	0.4945	0.4914	0.4900	0.4840	0.5214
(4) Washington, D.C. (DC)	0.4686	0.4322	0.5100	0.4390	0.3960	0.5401	0.5402	0.5255	0.5140
(5) Alaska (NAK)	0.3428	0.3565	0.3619	0.3589	0.3629	0.3457	0.3450	0.3462	0.3468
(6) Northern Australia, Tanami Desert (NAUS)	0.2988	0.3336	0.3535	0.3550	0.3612	0.2886	0.2340	0.2701	0.2930
(7) Pyrenee Mountains (PYRNES)	0.4199	0.4719	0.4773	0.4095	0.4063	0.3706	0.3594	0.3518	0.3662
(8) Spokane, Washington (SPOK)	0.3621	0.3051	0.3269	0.3584	0.3144	0.3093	0.3368	0.3385	0.3492
(9) Tehran, Iran (TEHRAN)	0.2762	0.4992	0.4919	0.5229	0.4665	0.3134	0.2581	0.1440	0.1985
(10) Xining, China (XINING)	0.3793	0.4099	0.4211	0.4596	0.4048	0.4893	0.5081	0.4699	0.4417
Elevation Angle = 1°									
(1) Ahaggar, Algeria (AHAGR)	0.2711	0.2582	0.2725	0.2458	0.2179	0.2203	0.2401	0.2005	0.1809
(2) Amazon Forest (AMFOR)	0.4021	0.3974	0.4135	0.3918	0.3670	0.3895	0.3913	0.3923	0.3763
(3) Bangkok, Thailand (BANGK)	0.3936	0.3847	0.3670	0.3846	0.4180	0.4009	0.3995	0.3937	0.4157
(4) Washington, D.C. (DC)	0.3872	0.3653	0.4220	0.3697	0.3351	0.4284	0.4280	0.4202	0.4132
(5) Alaska (NAK)	0.3007	0.3083	0.3127	0.3098	0.3129	0.2912	0.2921	0.2921	0.2942
(6) Northern Australia, Tanami Desert (NAUS)	0.2646	0.2862	0.3004	0.3015	0.3070	0.2530	0.2163	0.2401	0.2558
(7) Pyrenee Mountains (PYRNES)	0.3539	0.3784	0.3866	0.3356	0.3370	0.3109	0.3040	0.2993	0.3081
(8) Spokane, Washington (SPOK)	0.3088	0.2683	0.2863	0.3067	0.2720	0.2716	0.2938	0.2949	0.3071
(9) Tehran, Iran (TEHRAN)	0.2474	0.3971	0.3963	0.4058	0.3795	0.2773	0.2330	0.1428	0.1844
(10) Xining, China (XINING)	0.3305	0.3530	0.3613	0.3818	0.3455	0.4051	0.4219	0.3936	0.3707
Elevation Angle = 3°									
(1) Ahaggar, Algeria (AHAGR)	0.1752	0.1662	0.1737	0.1600	0.1447	0.1414	0.1506	0.1313	0.1216
(2) Amazon Forest (AMFOR)	0.2421	0.2403	0.2489	0.2375	0.2251	0.2281	0.2285	0.2286	0.2225
(3) Bangkok, Thailand (BANGK)	0.2390	0.2363	0.2271	0.2372	0.2544	0.2381	0.2371	0.2341	0.2436
(4) Washington, D.C. (DC)	0.2337	0.2243	0.2529	0.2262	0.2077	0.2466	0.2464	0.2430	0.2392
(5) Alaska (NAK)	0.1917	0.1947	0.1972	0.1954	0.1971	0.1790	0.1801	0.1795	0.1809
(6) Northern Australia, Tanami Desert (NAUS)	0.1713	0.1804	0.1875	0.1880	0.1912	0.1580	0.1414	0.1521	0.1594
(7) Pyrenee Mountains (PYRNES)	0.2176	0.2248	0.2302	0.2039	0.2056	0.1894	0.1863	0.1842	0.1880
(8) Spokane, Washington (SPOK)	0.1939	0.1741	0.1838	0.1930	0.1742	0.1724	0.1838	0.1839	0.1908
(9) Tehran, Iran (TEHRAN)	0.1632	0.2343	0.2351	0.2362	0.2273	0.1750	0.1513	0.1030	0.1254
(10) Xining, China (XINING)	0.2110	0.2208	0.2249	0.2324	0.2156	0.2411	0.2507	0.2361	0.2223
Elevation Angle = 5°									
(1) Ahaggar, Algeria (AHAGR)	0.1224	0.1163	0.1211	0.1123	0.1024	0.0983	0.1041	0.0920	0.0857
(2) Amazon Forest (AMFOR)	0.1652	0.1642	0.1698	0.1624	0.1545	0.1537	0.1539	0.1539	0.1503
(3) Bangkok, Thailand (BANGK)	0.1634	0.1619	0.1561	0.1627	0.1737	0.1610	0.1603	0.1584	0.1642
(4) Washington, D.C. (DC)	0.1597	0.1540	0.1722	0.1551	0.1432	0.1653	0.1652	0.1631	0.1606
(5) Alaska (NAK)	0.1332	0.1349	0.1366	0.1354	0.1365	0.1227	0.1235	0.1231	0.1240
(6) Northern Australia, Tanami Desert (NAUS)	0.1197	0.1252	0.1297	0.1300	0.1322	0.1087	0.0984	0.1050	0.1096
(7) Pyrenee Mountains (PYRNES)	0.1496	0.1533	0.1570	0.1402	0.1413	0.1294	0.1274	0.1261	0.1284
(8) Spokane, Washington (SPOK)	0.1343	0.1219	0.1281	0.1338	0.1216	0.1190	0.1261	0.1262	0.1305
(9) Tehran, Iran (TEHRAN)	0.1148	0.1592	0.1599	0.1601	0.1550	0.1204	0.1051	0.0741	0.0887
(10) Xining, China (XINING)	0.1465	0.1523	0.1549	0.1591	0.1487	0.1631	0.1693	0.1599	0.1506
Elevation Angle = 10°									
(1) Ahaggar, Algeria (AHAGR)	0.0668	0.0635	0.0660	0.0616	0.0564	0.0534	0.0563	0.0502	0.0470
(2) Amazon Forest (AMFOR)	0.0887	0.0882	0.0911	0.0873	0.0833	0.0817	0.0818	0.0818	0.0800
(3) Bangkok, Thailand (BANGK)	0.0878	0.0872	0.0842	0.0876	0.0932	0.0858	0.0854	0.0844	0.0873
(4) Washington, D.C. (DC)	0.0859	0.0830	0.0923	0.0836	0.0774	0.0876	0.0876	0.0865	0.0852
(5) Alaska (NAK)	0.0724	0.0732	0.0741	0.0735	0.0741	0.0660	0.0665	0.0662	0.0667
(6) Northern Australia, Tanami Desert (NAUS)	0.0654	0.0681	0.0704	0.0705	0.0716	0.0586	0.0534	0.0568	0.0591
(7) Pyrenee Mountains (PYRNES)	0.0808	0.0824	0.0843	0.0757	0.0763	0.0694	0.0684	0.0678	0.0689
(8) Spokane, Washington (SPOK)	0.0729	0.0666	0.0698	0.0727	0.0663	0.0643	0.0679	0.0679	0.0701
(9) Tehran, Iran (TEHRAN)	0.0629	0.0853	0.0857	0.0857	0.0833	0.0649	0.0570	0.0412	0.0487
(10) Xining, China (XINING)	0.0795	0.0823	0.0836	0.0856	0.0804	0.0869	0.0901	0.0852	0.0804

Angle Error (degrees) for Selected Areas-of-Interest

ECM, HIRAS and MRF Data for November 15, 1995

(0000, 0600, 1200 and 1800 Hours)

AOI	ECM	HIRAS 0000	HIRAS 0600	HIRAS 1200	HIRAS 1800	MRF (11/15/95) 0000	MRF (11/15/95) 0600	MRF (11/15/95) 1200	MRF (11/15/95) 1800
	Elevation Angle = 0°								
(1) Ahaggar, Algeria (AHAGR)	0.2812	0.3412	0.3620	0.3312	0.3312	0.2764	0.2830	0.2277	0.2409
(2) Amazon Forest (AMFOR)	0.4818	0.4736	0.4991	0.4336	0.4336	0.4540	0.4473	0.4498	0.4200
(3) Bangkok, Thailand (BANGK)	0.4647	0.4322	0.3806	0.4344	0.4344	0.4244	0.4380	0.4255	0.4208
(4) Washington, D.C. (DC)	0.3713	0.3533	0.3872	0.3409	0.3409	0.2908	0.2825	0.2830	0.2829
(5) Alaska (NAK)	0.3189	0.3032	0.3004	0.3003	0.3003	0.2881	0.2839	0.2920	0.2930
(6) Northern Australia, Tanami Desert (NAUS)	0.3131	0.3342	0.3307	0.3404	0.3404	0.3370	0.3005	0.3500	0.3825
(7) Pyrenee Mountains (PYRNES)	0.3661	0.3739	0.3793	0.3716	0.3716	0.3090	0.3030	0.3055	0.3086
(8) Spokane, Washington (SPOK)	0.3338	0.3170	0.3208	0.3192	0.3192	0.3530	0.3499	0.3418	0.3449
(9) Tehran, Iran (TEHRAN)	0.3376	0.4199	0.4083	0.4152	0.4152	0.2314	0.2207	0.2101	0.2403
(10) Xining, China (XINING)	0.3433	0.3381	0.3487	0.3551	0.3551	0.2934	0.2590	0.2698	0.2841
	Elevation Angle = 1°								
(1) Ahaggar, Algeria (AHAGR)	0.2489	0.2891	0.3042	0.2813	0.2813	0.2396	0.2446	0.2067	0.2127
(2) Amazon Forest (AMFOR)	0.4011	0.3926	0.4122	0.3638	0.3638	0.3813	0.3758	0.3768	0.3601
(3) Bangkok, Thailand (BANGK)	0.3918	0.3698	0.3302	0.3767	0.3767	0.3638	0.3688	0.3631	0.3598
(4) Washington, D.C. (DC)	0.3119	0.2999	0.3229	0.2877	0.2877	0.2595	0.2531	0.2511	0.2496
(5) Alaska (NAK)	0.2827	0.2719	0.2699	0.2697	0.2697	0.2535	0.2518	0.2548	0.2557
(6) Northern Australia, Tanami Desert (NAUS)	0.2798	0.2923	0.2942	0.3019	0.3019	0.2954	0.2728	0.3031	0.3250
(7) Pyrenee Mountains (PYRNES)	0.3126	0.3151	0.3194	0.3144	0.3144	0.2680	0.2645	0.2662	0.2683
(8) Spokane, Washington (SPOK)	0.2891	0.2773	0.2801	0.2780	0.2780	0.3019	0.3010	0.2957	0.2973
(9) Tehran, Iran (TEHRAN)	0.2936	0.3428	0.3375	0.3412	0.3412	0.2069	0.2000	0.1922	0.2141
(10) Xining, China (XINING)	0.2972	0.2926	0.2996	0.3021	0.3021	0.2566	0.2262	0.2355	0.2487
	Elevation Angle = 3°								
(1) Ahaggar, Algeria (AHAGR)	0.1630	0.1813	0.1888	0.1769	0.1769	0.1513	0.1537	0.1355	0.1373
(2) Amazon Forest (AMFOR)	0.2424	0.2382	0.2485	0.2238	0.2238	0.2286	0.2257	0.2262	0.2195
(3) Bangkok, Thailand (BANGK)	0.2390	0.2282	0.2077	0.2342	0.2342	0.2226	0.2234	0.2218	0.2201
(4) Washington, D.C. (DC)	0.1926	0.1870	0.1980	0.1796	0.1796	0.1653	0.1617	0.1600	0.1585
(5) Alaska (NAK)	0.1808	0.1756	0.1747	0.1746	0.1746	0.1604	0.1599	0.1604	0.1607
(6) Northern Australia, Tanami Desert (NAUS)	0.1824	0.1872	0.1896	0.1937	0.1937	0.1866	0.1765	0.1898	0.1999
(7) Pyrenee Mountains (PYRNES)	0.1949	0.1948	0.1972	0.1949	0.1949	0.1676	0.1662	0.1670	0.1679
(8) Spokane, Washington (SPOK)	0.1834	0.1776	0.1791	0.1776	0.1776	0.1860	0.1854	0.1820	0.1829
(9) Tehran, Iran (TEHRAN)	0.1864	0.2071	0.2054	0.2069	0.2069	0.1349	0.1319	0.1279	0.1379
(10) Xining, China (XINING)	0.1878	0.1847	0.1878	0.1880	0.1880	0.1611	0.1447	0.1496	0.1569
	Elevation Angle = 5°								
(1) Ahaggar, Algeria (AHAGR)	0.1145	0.1257	0.1305	0.1228	0.1228	0.1046	0.1061	0.0946	0.0956
(2) Amazon Forest (AMFOR)	0.1654	0.1629	0.1695	0.1537	0.1537	0.1547	0.1529	0.1532	0.1492
(3) Bangkok, Thailand (BANGK)	0.1635	0.1566	0.1435	0.1609	0.1609	0.1515	0.1518	0.1509	0.1499
(4) Washington, D.C. (DC)	0.1330	0.1294	0.1363	0.1245	0.1245	0.1141	0.1117	0.1106	0.1095
(5) Alaska (NAK)	0.1256	0.1224	0.1219	0.1218	0.1218	0.1107	0.1105	0.1107	0.1109
(6) Northern Australia, Tanami Desert (NAUS)	0.1275	0.1303	0.1319	0.1346	0.1346	0.1285	0.1222	0.1304	0.1365
(7) Pyrenee Mountains (PYRNES)	0.1347	0.1344	0.1359	0.1345	0.1345	0.1153	0.1145	0.1149	0.1156
(8) Spokane, Washington (SPOK)	0.1274	0.1238	0.1247	0.1237	0.1237	0.1273	0.1268	0.1245	0.1251
(9) Tehran, Iran (TEHRAN)	0.1295	0.1420	0.1411	0.1420	0.1420	0.0944	0.0925	0.0899	0.0961
(10) Xining, China (XINING)	0.1305	0.1283	0.1301	0.1301	0.1301	0.1112	0.1005	0.1037	0.1084
	Elevation Angle = 10°								
(1) Ahaggar, Algeria (AHAGR)	0.0627	0.0683	0.0708	0.0668	0.0668	0.0566	0.0574	0.0515	0.0520
(2) Amazon Forest (AMFOR)	0.0888	0.0876	0.0910	0.0829	0.0829	0.0824	0.0815	0.0817	0.0797
(3) Bangkok, Thailand (BANGK)	0.0879	0.0843	0.0777	0.0867	0.0867	0.0810	0.0810	0.0807	0.0801
(4) Washington, D.C. (DC)	0.0720	0.0702	0.0737	0.0676	0.0676	0.0616	0.0604	0.0598	0.0592
(5) Alaska (NAK)	0.0683	0.0667	0.0664	0.0664	0.0664	0.0598	0.0597	0.0598	0.0599
(6) Northern Australia, Tanami Desert (NAUS)	0.0696	0.0709	0.0718	0.0731	0.0731	0.0692	0.0660	0.0701	0.0732
(7) Pyrenee Mountains (PYRNES)	0.0729	0.0727	0.0735	0.0728	0.0728	0.0622	0.0618	0.0620	0.0623
(8) Spokane, Washington (SPOK)	0.0693	0.0674	0.0679	0.0674	0.0674	0.0684	0.0681	0.0668	0.0671
(9) Tehran, Iran (TEHRAN)	0.0704	0.0766	0.0761	0.0766	0.0766	0.0514	0.0505	0.0491	0.0522
(10) Xining, China (XINING)	0.0709	0.0697	0.0707	0.0706	0.0706	0.0601	0.0546	0.0562	0.0586

Appendix H

TIME DELAYS AND ANGLE ERRORS FOR HOURS AND SEASONS/ANGLES BY MODELS

Time delays and angle errors are compared for 10 areas of interest by seasons and elevation angles by tropospheric models

Time Delay (ns) for 10 Selected Areas-of-Interest
MRF, Hopfield, Goad and Exponential Model
at 0000 Hours

AOI	February 15th				May 15th				August 15th				November 15th			
Elevation Angle = 0°	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	334.0	284.9	288.8	336.3	334.0	266.3	275.2	315.5	334.0	271.6	282.5	327.5	334.0	283.0	288.4	337.2
(2) Amazon Forest (AMFOR)	431.7	330.0	338.6	424.6	444.9	335.2	343.9	435.3	423.4	326.1	335.2	418.2	429.2	328.2	337.4	423.4
(3) Bangkok, Thailand (BANGK)	430.0	329.3	338.2	418.8	442.8	333.4	343.0	437.5	449.3	335.5	344.9	442.7	429.9	326.9	336.0	426.6
(4) Washington, D.C. (DC)	337.2	294.1	291.3	341.0	411.7	321.9	328.0	406.5	444.4	333.7	344.2	433.8	344.8	295.4	293.9	348.1
(5) Alaska (NAK)	342.2	296.1	292.8	347.1	347.5	298.7	296.7	352.6	364.7	302.8	303.7	366.6	336.9	292.7	291.0	342.4
(6) Northern Australia, Tanami Desert (NAUS)	400.4	313.8	324.5	395.8	368.3	295.7	303.4	365.4	336.7	287.8	291.7	340.6	386.0	304.3	312.8	382.4
(7) Pyrenee Mountains (PYRNES)	345.1	297.1	294.2	349.8	358.1	299.7	302.0	361.7	376.8	306.5	312.4	377.2	349.2	295.5	295.9	353.6
(8) Spokane, Washington (SPOK)	333.3	296.3	289.3	337.4	364.5	298.3	304.7	368.2	359.8	294.7	300.8	360.4	374.3	307.5	310.1	375.5
(9) Tehran, Iran (TEHRAN)	364.4	302.5	305.0	367.2	378.2	305.5	311.2	378.8	363.2	291.9	303.0	361.6	320.8	275.7	280.7	322.0
(10) Xining, China (XINING)	348.3	300.3	298.5	351.3	358.7	296.9	302.2	362.4	450.5	337.3	345.5	447.3	345.0	293.3	295.8	350.2
Elevation Angle = 1°	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	233.0	199.4	203.1	235.9	221.7	187.2	195.6	224.7	229.8	189.3	199.6	231.2	232.9	197.5	202.7	236.8
(2) Amazon Forest (AMFOR)	284.7	221.9	230.4	281.0	291.6	224.7	233.4	285.9	278.7	219.6	228.6	279.0	285.5	220.7	229.8	281.0
(3) Bangkok, Thailand (BANGK)	280.9	221.3	230.2	274.7	291.3	223.4	232.9	290.2	296.4	224.6	233.9	294.3	288.9	219.9	228.9	285.9
(4) Washington, D.C. (DC)	235.5	206.6	204.2	238.6	270.3	218.1	224.3	271.1	287.9	223.4	233.8	284.0	238.5	205.8	204.6	241.9
(5) Alaska (NAK)	235.8	207.1	204.1	241.7	239.1	208.2	206.5	244.9	249.5	209.6	210.7	253.2	233.1	204.9	203.4	238.6
(6) Northern Australia, Tanami Desert (NAUS)	268.2	212.3	222.7	266.9	255.4	203.6	211.1	251.6	233.9	200.8	204.6	238.1	265.3	207.9	216.2	261.1
(7) Pyrenee Mountains (PYRNES)	237.4	207.8	205.2	243.0	245.1	207.3	209.7	250.2	256.0	210.0	215.9	258.5	240.7	205.8	206.3	245.6
(8) Spokane, Washington (SPOK)	231.4	208.6	202.1	235.1	249.9	205.0	211.3	254.0	248.5	203.1	209.1	249.5	255.2	211.6	214.3	257.4
(9) Tehran, Iran (TEHRAN)	249.5	209.0	211.5	253.6	258.3	209.4	215.0	259.6	250.9	200.2	210.8	249.1	227.0	194.0	198.8	228.0
(10) Xining, China (XINING)	240.9	209.7	208.3	244.0	246.5	205.0	210.2	250.9	297.7	226.0	234.1	297.6	239.4	204.4	206.9	244.9
Elevation Angle = 3°	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	132.7	116.7	119.6	135.0	128.4	109.9	116.3	130.8	132.0	110.5	118.4	133.2	132.6	115.5	119.4	135.6
(2) Amazon Forest (AMFOR)	153.6	126.1	132.8	150.2	156.5	127.4	134.2	151.6	150.7	125.0	131.9	150.5	154.6	125.5	132.6	150.6
(3) Bangkok, Thailand (BANGK)	150.9	125.8	132.7	145.5	156.6	126.7	134.0	155.3	159.8	127.3	134.5	157.9	157.4	125.1	132.1	154.8
(4) Washington, D.C. (DC)	133.5	121.3	119.6	136.2	146.2	124.7	129.6	146.3	153.8	126.6	134.6	150.2	133.9	120.1	119.4	136.7
(5) Alaska (NAK)	132.5	121.2	119.2	137.1	134.0	121.6	120.5	138.6	139.5	121.7	122.8	142.2	131.2	120.0	119.0	135.6
(6) Northern Australia, Tanami Desert (NAUS)	147.0	121.3	129.2	145.6	143.7	117.8	123.6	140.8	132.6	117.4	120.3	135.6	147.8	119.6	126.0	144.5
(7) Pyrenee Mountains (PYRNES)	133.2	121.6	119.8	137.5	137.0	120.4	122.4	140.8	142.2	121.1	125.7	143.9	135.1	120.1	120.6	138.9
(8) Spokane, Washington (SPOK)	130.5	122.6	118.0	133.5	139.3	118.5	123.4	142.3	139.6	117.7	122.3	140.4	141.7	122.4	124.7	143.3
(9) Tehran, Iran (TEHRAN)	139.3	121.2	123.3	142.4	143.6	120.8	125.2	144.4	141.0	115.5	123.6	139.4	130.8	114.1	117.7	131.9
(10) Xining, China (XINING)	135.5	122.6	121.7	137.9	138.1	118.9	122.9	141.3	160.3	128.1	134.5	160.0	135.2	119.3	121.4	139.6
Elevation Angle = 5°	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	89.5	79.8	82.0	91.2	87.0	75.2	80.0	89.0	89.3	75.5	81.4	90.2	89.4	78.9	81.9	91.6
(2) Amazon Forest (AMFOR)	101.9	85.5	90.5	99.1	103.7	86.3	91.4	99.7	100.2	84.7	90.0	99.5	102.6	85.0	90.4	99.4
(3) Bangkok, Thailand (BANGK)	100.1	85.2	90.4	95.6	103.8	85.8	91.3	102.4	106.0	86.1	91.6	104.2	104.6	84.8	90.1	102.5
(4) Washington, D.C. (DC)	89.8	83.0	81.7	91.9	97.2	84.7	88.4	96.7	101.9	85.7	91.7	98.7	89.8	82.0	81.5	91.9
(5) Alaska (NAK)	88.9	82.8	81.4	92.3	89.9	83.1	82.3	93.2	93.5	83.0	83.9	95.4	88.0	82.0	81.3	91.3
(6) Northern Australia, Tanami Desert (NAUS)	98.0	82.3	88.3	96.6	96.4	80.3	84.6	94.4	89.4	80.2	82.4	91.5	98.9	81.4	86.2	96.5
(7) Pyrenee Mountains (PYRNES)	89.3	83.1	81.8	92.5	91.8	82.1	83.6	94.5	95.2	82.4	85.9	96.2	90.7	82.0	82.5	93.4
(8) Spokane, Washington (SPOK)	87.5	83.9	80.5	90.0	93.3	80.7	84.4	95.4	93.6	80.2	83.7	94.2	94.8	83.3	85.1	95.8
(9) Tehran, Iran (TEHRAN)	93.3	82.6	84.3	95.5	96.0	82.2	85.6	96.6	94.6	78.6	84.7	93.4	88.4	78.1	80.8	89.5
(10) Xining, China (XINING)	90.9	83.8	83.1	92.8	92.6	81.0	84.1	94.9	106.3	86.7	91.6	105.7	90.9	81.5	83.1	94.1
Elevation Angle = 10°	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	48.0	43.3	44.6	49.0	46.9	40.8	43.7	48.0	48.0	40.9	44.4	48.6	48.0	42.8	44.6	49.2
(2) Amazon Forest (AMFOR)	54.2	46.0	49.1	52.4	55.1	46.5	49.6	52.6	53.3	45.6	48.8	52.7	54.5	45.8	49.0	52.6
(3) Bangkok, Thailand (BANGK)	53.2	45.9	49.0	50.5	55.1	46.2	49.5	54.2	56.3	46.4	49.7	55.2	55.6	45.7	48.9	54.3
(4) Washington, D.C. (DC)	48.1	45.1	44.4	49.3	51.7	45.7	47.9	51.3	54.1	46.1	49.8	52.1	48.0	44.5	44.2	49.2
(5) Alaska (NAK)	47.6	44.9	44.1	49.5	48.0	45.0	44.6	50.0	50.0	44.9	45.5	51.1	47.1	44.5	44.1	49.0
(6) Northern Australia, Tanami Desert (NAUS)	52.3	44.4	48.0	51.3	51.6	43.4	46.0	50.4	48.0	43.5	44.8	49.1	52.8	44.0	46.8	51.4
(7) Pyrenee Mountains (PYRNES)	47.8	45.1	44.4	49.6	49.1	44.4	45.4	50.6	50.9	44.5	46.6	51.4	48.5	44.4	44.8	50.1
(8) Spokane, Washington (SPOK)	46.8	45.6	43.6	48.3	49.8	43.7	45.9	51.0	50.1	43.4	45.5	50.4	50.6	45.1	46.2	51.2
(9) Tehran, Iran (TEHRAN)	49.9	44.7	45.7	51.1	51.2	44.4	46.5	51.5	50.7	42.5	46.1	49.9	47.6	42.4	44.0	48.2
(10) Xining, China (XINING)	48.7	45.4	45.1	49.7	49.5	43.9	45.7	50.8	56.4	46.7	49.6	55.9	48.7	44.2	45.1	50.6

Time Delay (ns) for 10 Selected Areas-of-Interest
MRF, Hopfield, Goad and Exponential Model
at 0600 Hours

AOI	Elevation Angle = 0°															
	February 15th				May 15th				August 15th				November 15th			
	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	334.0	288.8	291.1	341.4	334.0	271.2	278.2	320.7	334.0	278.2	287.2	335.7	334.0	285.8	289.9	339.3
(2) Amazon Forest (AMFOR)	430.3	329.6	337.4	423.6	440.5	333.7	341.7	432.8	423.9	326.3	334.3	418.4	425.7	326.8	335.3	420.3
(3) Bangkok, Thailand (BANGK)	415.8	321.6	331.5	408.7	448.9	336.3	346.0	440.7	446.3	334.1	343.9	439.3	429.1	326.6	335.6	424.9
(4) Washington, D.C. (DC)	340.3	295.8	292.2	343.7	402.3	318.7	323.7	397.9	444.9	335.1	343.9	433.1	338.9	293.5	291.2	342.0
(5) Alaska (NAK)	342.7	296.5	293.1	347.8	348.2	299.1	297.1	353.1	366.3	303.6	304.6	368.0	337.3	293.1	291.2	342.5
(6) Northern Australia, Tanami Desert (NAUS)	368.7	295.7	309.3	366.8	361.0	292.4	302.3	358.6	322.7	272.4	281.6	325.7	375.0	296.9	308.2	371.5
(7) Pyrenee Mountains (PYRNES)	345.1	297.2	294.6	350.1	354.3	299.0	301.9	358.1	373.3	306.0	312.5	374.1	348.1	294.7	295.6	352.4
(8) Spokane, Washington (SPOK)	338.6	301.1	292.4	343.0	387.8	312.5	316.6	389.0	368.6	301.9	306.1	368.6	371.0	306.9	308.7	372.2
(9) Tehran, Iran (TEHRAN)	365.6	303.2	305.6	368.4	368.8	297.1	306.4	369.4	338.5	274.1	288.9	336.8	318.3	272.1	279.2	319.4
(10) Xining, China (XINING)	339.4	288.8	291.8	343.3	325.0	270.4	281.9	328.5	462.4	340.9	351.6	455.2	327.5	277.4	284.6	331.7
	Elevation Angle = 1°															
	February 15th				May 15th				August 15th				November 15th			
	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	233.2	201.9	204.3	239.1	223.9	190.6	197.1	227.8	233.3	193.5	202.1	235.8	234.0	199.6	203.5	237.8
(2) Amazon Forest (AMFOR)	283.9	221.9	229.7	280.7	290.0	224.1	232.0	286.0	278.6	220.0	227.9	279.0	283.6	220.1	228.6	279.5
(3) Bangkok, Thailand (BANGK)	276.5	216.9	226.6	271.1	291.4	224.9	234.5	290.4	294.4	223.8	233.4	291.9	287.1	219.8	228.7	284.5
(4) Washington, D.C. (DC)	237.9	207.8	204.6	240.6	265.2	216.7	221.8	266.6	288.2	224.7	233.5	282.8	234.8	205.0	203.1	237.9
(5) Alaska (NAK)	236.0	207.3	204.3	242.0	239.5	208.4	206.8	245.1	250.6	209.9	211.2	253.8	233.7	205.2	203.6	238.7
(6) Northern Australia, Tanami Desert (NAUS)	255.1	201.4	214.3	253.1	252.1	201.0	210.5	248.0	227.8	190.5	199.2	229.7	260.2	202.8	213.7	255.3
(7) Pyrenee Mountains (PYRNES)	237.6	207.7	205.5	243.2	243.3	206.8	209.7	248.3	254.5	209.6	215.9	256.8	240.3	205.1	206.1	244.9
(8) Spokane, Washington (SPOK)	234.2	211.7	203.8	238.4	262.2	213.3	217.6	264.7	252.4	207.5	211.8	253.0	253.0	211.5	213.5	254.9
(9) Tehran, Iran (TEHRAN)	250.3	209.4	211.9	254.1	253.8	203.7	212.7	254.2	237.7	189.2	203.2	235.8	225.9	191.4	198.0	226.6
(10) Xining, China (XINING)	235.6	201.4	204.3	240.0	228.2	188.1	199.0	232.3	304.2	227.2	237.8	299.2	229.5	193.9	200.6	234.1
	Elevation Angle = 3°															
	February 15th				May 15th				August 15th				November 15th			
	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	132.1	118.1	120.0	136.5	129.1	111.9	116.9	132.1	133.2	112.8	119.4	135.1	133.0	116.7	119.7	135.9
(2) Amazon Forest (AMFOR)	153.3	126.3	132.4	150.3	156.2	127.3	133.5	152.6	150.6	125.3	131.5	150.4	153.8	125.3	131.9	150.2
(3) Bangkok, Thailand (BANGK)	150.1	123.6	131.1	145.4	155.6	127.4	134.8	154.4	158.8	126.8	134.3	156.6	156.2	125.0	132.0	154.0
(4) Washington, D.C. (DC)	135.0	122.0	119.7	137.3	144.1	124.2	128.4	144.6	154.0	127.5	134.3	149.1	132.1	119.9	118.6	134.6
(5) Alaska (NAK)	132.5	121.3	119.2	137.2	134.2	121.7	120.7	138.6	140.0	121.9	123.0	142.3	131.6	120.2	119.1	135.6
(6) Northern Australia, Tanami Desert (NAUS)	143.1	115.6	125.4	141.4	142.5	116.2	123.5	139.5	130.7	111.5	118.1	132.3	146.0	116.7	125.0	142.3
(7) Pyrenee Mountains (PYRNES)	133.3	121.5	120.0	137.7	136.3	120.0	122.4	140.1	141.7	120.8	125.8	143.2	135.0	119.6	120.6	138.6
(8) Spokane, Washington (SPOK)	131.5	124.4	118.7	135.0	144.2	122.7	126.2	145.8	140.5	120.0	123.4	140.9	140.5	122.4	124.2	141.7
(9) Tehran, Iran (TEHRAN)	139.6	121.4	123.5	142.5	141.9	117.5	124.4	142.2	135.7	109.7	120.2	134.3	130.4	112.4	117.5	131.3
(10) Xining, China (XINING)	133.2	117.6	119.9	136.7	130.6	109.6	117.9	133.9	162.8	128.3	136.4	158.6	131.1	113.4	118.5	134.9
	Elevation Angle = 5°															
	February 15th				May 15th				August 15th				November 15th			
	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	89.0	80.7	82.2	92.1	87.4	76.6	80.3	89.7	89.9	77.0	82.0	91.2	89.7	79.7	82.1	91.8
(2) Amazon Forest (AMFOR)	101.8	85.6	90.2	99.2	103.6	86.2	90.9	100.6	100.0	85.0	89.7	99.4	102.2	85.0	89.9	99.2
(3) Bangkok, Thailand (BANGK)	99.8	83.8	89.5	96.0	103.0	86.2	91.8	101.6	105.3	85.8	91.5	103.3	103.8	84.7	90.0	101.9
(4) Washington, D.C. (DC)	90.8	83.5	81.8	92.6	95.9	84.4	87.5	95.8	102.0	86.3	91.5	97.9	88.6	81.9	81.0	90.5
(5) Alaska (NAK)	88.9	82.9	81.4	92.3	90.0	83.1	82.4	93.2	93.9	83.1	84.0	95.5	88.4	82.2	81.4	91.4
(6) Northern Australia, Tanami Desert (NAUS)	95.9	78.5	85.9	94.6	95.7	79.1	84.6	93.6	88.3	76.2	81.2	89.6	97.9	79.4	85.6	95.2
(7) Pyrenee Mountains (PYRNES)	89.4	83.0	82.0	92.6	91.4	81.8	83.7	94.1	94.9	82.2	86.0	95.9	90.6	81.7	82.4	93.3
(8) Spokane, Washington (SPOK)	88.2	85.1	80.9	90.9	96.2	83.4	86.1	97.2	94.0	81.7	84.3	94.2	94.0	83.4	84.8	94.8
(9) Tehran, Iran (TEHRAN)	93.5	82.8	84.4	95.5	95.0	80.0	85.2	95.2	91.6	74.8	82.7	90.6	88.3	76.9	80.7	89.1
(10) Xining, China (XINING)	89.6	80.3	82.1	92.2	88.2	74.9	81.1	90.7	107.7	86.7	92.9	104.3	88.5	77.5	81.4	91.4
	Elevation Angle = 10°															
	February 15th				May 15th				August 15th				November 15th			
	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	47.7	43.8	44.7	49.5	47.1	41.6	43.8	48.4	48.3	41.8	44.7	49.1	48.1	43.3	44.6	49.3
(2) Amazon Forest (AMFOR)	54.1	46.1	48.9	52.4	55.0	46.4	49.3	53.2	53.2	45.8	48.6	52.7	54.3	45.8	48.8	52.5
(3) Bangkok, Thailand (BANGK)	53.1	45.2	48.6	50.8	54.7	46.4	49.8	53.6	56.0	46.2	49.6	54.7	55.2	45.7	48.8	54.0
(4) Washington, D.C. (DC)	48.7	45.3	44.4	49.7	51.1	45.6	47.5	50.8	54.2	46.5	49.6	51.6	47.4	44.4	44.0	48.5
(5) Alaska (NAK)	47.6	45.0	44.1	49.5	48.1	45.1	44.7	50.0	50.2	45.0	45.6	51.1	47.3	44.6	44.2	49.0
(6) Northern Australia, Tanami Desert (NAUS)	51.3	42.4	46.8	50.5	51.2	42.8	46.1	50.1	47.5	41.4	44.3	48.2	52.3	42.9	46.6	50.8
(7) Pyrenee Mountains (PYRNES)	47.8	45.0	44.5	49.6	48.9	44.3	45.4	50.4	50.7	44.4	46.7	51.2	48.5	44.3	44.8	50.0
(8) Spokane, Washington (SPOK)	47.1	46.2	43.8	48.7	51.2	45.1	46.7	51.7	50.2	44.2	45.8	50.3	50.2	45.1	46.0	50.6
(9) Tehran, Iran (TEHRAN)	49.9	44.8	45.8	51.1	50.8	43.3	46.3	50.9	49.2	40.5	45.1	48.6	47.5	41.8	44.0	48.1
(10) Xining, China (XINING)	48.0	43.5	44.6	49.5	47.4	40.6	44.2	48.8	57.1	46.7	50.3	55.0	47.5	42.0	44.3	49.2

Time Delay (ns) for 10 Selected Areas-of-Interest
MRF, Hopfield, Goad and Exponential Model
at 1200 Hours

AOI	February 15th				May 15th				August 15th				November 15th			
Elevation Angle = 0°																
	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	334.0	271.8	280.8	325.1	334.0	255.2	269.6	305.8	334.0	262.7	278.2	318.7	334.0	269.1	279.0	322.2
(2) Amazon Forest (AMFOR)	430.9	329.7	337.5	423.7	439.6	333.1	341.2	432.5	423.9	326.5	334.8	417.5	427.7	327.7	336.5	422.0
(3) Bangkok, Thailand (BANGK)	421.9	325.1	334.3	413.9	437.9	330.9	341.0	431.9	443.7	332.8	342.5	436.6	427.9	325.8	335.1	423.5
(4) Washington, D.C. (DC)	350.3	299.6	296.2	351.9	395.4	315.6	320.2	391.8	439.7	334.1	342.1	428.5	337.3	293.3	290.5	340.6
(5) Alaska (NAK)	341.4	295.9	292.6	346.8	348.0	299.3	296.9	352.6	364.7	303.1	304.1	366.5	337.5	294.1	291.4	342.6
(6) Northern Australia, Tanami Desert (NAUS)	382.0	303.7	316.0	378.7	372.2	300.5	308.3	368.8	332.2	283.2	288.4	335.7	388.3	305.7	315.6	385.3
(7) Pyrenee Mountains (PYRNES)	345.5	296.6	294.4	350.4	352.0	297.6	300.6	355.8	371.2	304.7	311.3	372.2	348.5	294.7	295.7	352.8
(8) Spokane, Washington (SPOK)	334.7	296.5	289.6	339.1	366.9	302.1	305.6	369.4	367.8	302.6	305.9	368.5	364.2	304.1	305.7	368.1
(9) Tehran, Iran (TEHRAN)	366.3	302.6	305.8	368.5	362.8	290.9	302.4	361.8	295.9	242.8	260.0	288.8	313.8	266.3	275.9	314.7
(10) Xining, China (XINING)	339.9	289.6	292.2	344.0	343.1	281.4	291.8	346.3	440.9	331.8	342.5	432.7	332.1	281.7	287.5	336.6
Elevation Angle = 1°																
	February 15th				May 15th				August 15th				November 15th			
	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	226.5	190.4	198.9	229.9	218.0	179.3	192.7	218.9	226.0	183.0	197.6	226.5	225.9	188.4	197.8	228.4
(2) Amazon Forest (AMFOR)	283.8	222.0	229.8	280.7	288.8	223.8	231.9	286.5	278.3	220.1	228.3	278.0	284.9	220.6	229.4	280.4
(3) Bangkok, Thailand (BANGK)	279.3	218.9	228.0	273.1	287.3	221.8	231.8	286.3	293.1	223.0	232.6	290.9	287.3	219.3	228.4	283.6
(4) Washington, D.C. (DC)	244.6	209.7	206.7	245.3	262.1	215.2	219.8	264.3	286.1	224.4	232.4	280.1	233.7	205.3	202.8	237.0
(5) Alaska (NAK)	235.0	206.9	204.1	241.6	239.5	208.8	206.7	244.9	249.4	209.7	210.9	252.8	233.4	206.1	203.7	238.8
(6) Northern Australia, Tanami Desert (NAUS)	261.4	206.2	218.0	259.6	258.1	206.3	213.8	253.3	232.1	197.8	202.9	235.4	265.8	208.1	217.8	263.0
(7) Pyrenee Mountains (PYRNES)	237.7	207.3	205.4	243.5	242.1	205.9	209.0	247.1	253.6	208.8	215.3	255.9	240.4	205.1	206.2	245.1
(8) Spokane, Washington (SPOK)	232.1	208.4	202.1	236.2	251.3	207.9	211.5	254.2	251.7	208.2	211.6	253.1	248.8	209.9	211.8	253.3
(9) Tehran, Iran (TEHRAN)	251.1	208.6	211.9	253.5	251.6	199.6	210.5	250.3	215.6	171.0	187.1	208.1	223.3	187.2	196.2	223.7
(10) Xining, China (XINING)	236.1	202.0	204.6	240.6	238.9	194.4	204.3	242.9	292.6	222.2	232.8	285.2	232.0	196.7	202.2	236.9
Elevation Angle = 3°																
	February 15th				May 15th				August 15th				November 15th			
	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	130.0	111.6	118.0	132.8	127.1	105.2	115.4	128.2	130.9	106.8	117.8	131.5	130.1	110.4	117.5	132.3
(2) Amazon Forest (AMFOR)	153.1	126.3	132.5	150.2	155.6	127.2	133.5	153.3	150.4	125.4	131.8	149.6	154.6	125.6	132.3	150.6
(3) Bangkok, Thailand (BANGK)	150.9	124.6	131.7	145.4	154.4	125.8	133.5	153.1	158.5	126.5	133.9	156.5	156.6	124.8	131.8	153.4
(4) Washington, D.C. (DC)	138.4	122.8	120.7	139.2	143.2	123.6	127.4	144.4	153.2	127.5	133.8	147.9	131.6	120.2	118.5	134.3
(5) Alaska (NAK)	132.0	121.1	119.1	137.1	134.3	122.0	120.6	138.5	139.3	121.8	122.9	141.9	131.4	120.8	119.2	135.7
(6) Northern Australia, Tanami Desert (NAUS)	145.7	118.1	127.1	144.2	145.0	119.1	124.9	141.3	132.2	115.7	119.6	134.6	147.8	119.5	126.9	145.5
(7) Pyrenee Mountains (PYRNES)	133.3	121.3	120.0	137.8	135.9	119.6	122.1	139.7	141.4	120.4	125.5	143.0	135.0	119.6	120.6	138.7
(8) Spokane, Washington (SPOK)	130.6	122.4	117.8	134.1	139.9	120.3	123.2	142.0	140.0	120.4	123.2	141.0	138.4	121.7	123.3	141.6
(9) Tehran, Iran (TEHRAN)	139.9	120.8	123.5	141.7	141.6	115.2	123.5	140.7	127.5	100.5	112.7	122.6	129.3	110.0	116.8	130.0
(10) Xining, China (XINING)	133.6	118.0	120.1	137.2	135.4	112.8	120.3	138.5	158.0	126.0	134.1	151.8	132.1	115.0	119.2	136.0
Elevation Angle = 5°																
	February 15th				May 15th				August 15th				November 15th			
	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	87.8	76.3	81.1	90.0	86.4	72.0	79.6	87.4	88.7	73.0	81.2	89.3	88.0	75.5	80.8	89.7
(2) Amazon Forest (AMFOR)	101.7	85.6	90.3	99.1	103.2	86.1	90.9	101.1	99.9	85.0	89.9	98.9	102.7	85.1	90.2	99.5
(3) Bangkok, Thailand (BANGK)	100.2	84.5	89.8	95.8	102.4	85.2	91.0	101.0	105.1	85.6	91.2	103.4	104.0	84.5	89.9	101.5
(4) Washington, D.C. (DC)	93.0	83.9	82.4	93.8	95.5	84.0	86.9	95.9	101.5	86.3	91.1	97.1	88.4	82.1	80.9	90.4
(5) Alaska (NAK)	88.6	82.8	81.3	92.3	90.0	83.3	82.3	93.2	93.4	83.1	84.0	95.2	88.2	82.6	81.4	91.4
(6) Northern Australia, Tanami Desert (NAUS)	97.6	80.2	87.0	96.3	97.2	81.1	85.5	94.6	89.2	79.0	82.0	90.9	98.8	81.2	86.8	97.1
(7) Pyrenee Mountains (PYRNES)	89.4	82.9	82.0	92.7	91.2	81.6	83.5	93.9	94.8	81.9	85.8	95.7	90.6	81.7	82.5	93.3
(8) Spokane, Washington (SPOK)	87.6	83.7	80.4	90.3	93.6	81.9	84.2	95.0	93.7	82.0	84.1	94.3	92.7	83.0	84.2	94.9
(9) Tehran, Iran (TEHRAN)	93.6	82.3	84.4	94.9	95.0	78.4	84.7	94.4	86.9	68.8	78.0	83.7	87.6	75.2	80.4	88.3
(10) Xining, China (XINING)	89.8	80.6	82.2	92.6	91.1	76.9	82.6	93.4	104.8	85.3	91.4	99.9	89.0	78.6	81.8	92.0
Elevation Angle = 10°																
	February 15th				May 15th				August 15th				November 15th			
	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	47.2	41.4	44.2	48.5	46.6	39.1	43.6	47.2	47.8	39.6	44.4	48.2	47.3	41.0	44.1	48.4
(2) Amazon Forest (AMFOR)	54.0	46.1	49.0	52.4	54.8	46.4	49.3	53.5	53.2	45.8	48.7	52.4	54.6	45.9	48.9	52.7
(3) Bangkok, Thailand (BANGK)	53.3	45.5	48.7	50.6	54.4	45.9	49.3	53.4	55.9	46.1	49.5	54.7	55.3	45.6	48.8	53.8
(4) Washington, D.C. (DC)	49.8	45.5	44.7	50.3	50.9	45.4	47.1	51.0	53.9	46.5	49.4	51.2	47.3	44.6	43.9	48.5
(5) Alaska (NAK)	47.4	44.9	44.1	49.5	48.1	45.2	44.7	49.9	50.0	45.0	45.6	50.9	47.2	44.8	44.2	49.1
(6) Northern Australia, Tanami Desert (NAUS)	52.1	43.3	47.3	51.3	52.0	43.8	46.5	50.5	47.9	42.9	44.6	48.9	52.8	43.8	47.2	51.7
(7) Pyrenee Mountains (PYRNES)	47.8	45.0	44.5	49.7	48.8	44.2	45.3	50.3	50.7	44.3	46.6	51.2	48.4	44.3	44.8	50.0
(8) Spokane, Washington (SPOK)	46.8	45.5	43.5	48.4	50.0	44.3	45.7	50.8	50.0	44.4	45.7	50.4	49.5	44.9	45.7	50.7
(9) Tehran, Iran (TEHRAN)	50.0	44.6	45.8	50.7	50.8	42.4	46.1	50.5	47.0	37.4	42.8	45.3	47.1	40.9	43.9	47.7
(10) Xining, China (XINING)	48.1	43.7	44.7	49.7	48.9	41.6	45.0	50.1	55.6	45.9	49.6	52.8	47.8	42.6	44.5	49.5

Time Delay (ns) for 10 Selected Areas-of-Interest
MRF, Hopfield, Goad and Exponential Model
at 1800 Hours

AOI	February 15th				May 15th				August 15th				November 15th			
	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.
Elevation Angle = 0°																
(1) Ahaggar, Algeria (AHAGR)	334.0	272.6	280.9	324.2	334.0	253.8	267.7	302.5	334.0	255.9	271.2	307.8	334.0	271.1	280.2	323.2
(2) Amazon Forest (AMFOR)	431.5	330.1	339.5	424.0	441.8	333.3	342.7	434.2	416.7	323.6	333.8	411.5	419.4	323.2	333.5	414.4
(3) Bangkok, Thailand (BANGK)	425.6	326.9	336.2	416.4	456.8	339.8	349.3	446.2	454.7	337.9	347.3	444.7	425.7	325.1	334.3	421.2
(4) Washington, D.C. (DC)	362.3	302.8	302.5	363.1	384.5	309.1	315.7	383.9	432.4	329.2	339.3	422.7	335.4	291.3	290.0	340.0
(5) Alaska (NAK)	342.1	296.5	293.0	347.7	348.4	299.5	297.1	353.0	365.7	304.1	305.0	367.8	338.1	294.2	291.8	342.6
(6) Northern Australia, Tanami Desert (NAUS)	397.3	311.2	321.3	392.4	380.7	305.9	311.8	377.8	338.3	289.2	292.4	341.5	396.6	311.2	319.6	393.1
(7) Pyrenee Mountains (PYRNES)	346.8	297.7	295.3	351.7	356.3	298.4	301.1	360.1	374.7	305.6	312.0	375.5	349.2	295.4	296.1	353.5
(8) Spokane, Washington (SPOK)	337.1	295.3	290.7	340.7	375.7	306.9	311.1	377.8	373.1	304.4	309.4	373.7	365.5	304.4	306.0	370.0
(9) Tehran, Iran (TEHRAN)	365.7	303.5	306.0	368.7	376.8	301.7	310.6	375.5	317.7	260.4	274.3	313.8	320.5	276.3	281.5	323.5
(10) Xining, China (XINING)	348.7	297.0	297.6	352.5	370.6	300.8	307.6	372.6	418.1	322.7	332.1	415.1	339.2	287.9	292.0	343.9
Elevation Angle = 1°																
	February 15th				May 15th				August 15th				November 15th			
	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	226.7	191.0	198.9	229.4	216.6	178.5	191.6	216.7	220.8	179.3	193.6	219.9	226.0	189.9	198.4	228.9
(2) Amazon Forest (AMFOR)	283.9	221.8	231.0	280.4	289.9	223.4	232.7	286.9	276.0	217.9	227.9	275.0	281.7	217.7	227.7	276.6
(3) Bangkok, Thailand (BANGK)	281.3	220.0	229.1	274.0	296.1	226.9	236.4	291.4	297.2	226.0	235.2	293.6	286.2	218.9	228.0	282.0
(4) Washington, D.C. (DC)	251.4	210.2	210.2	251.2	257.8	211.1	217.6	260.4	282.1	221.1	231.1	277.3	232.6	203.9	202.8	237.2
(5) Alaska (NAK)	235.2	207.3	204.3	242.1	239.8	208.8	206.9	245.1	250.0	210.3	211.4	253.5	233.8	206.1	204.1	238.6
(6) Northern Australia, Tanami Desert (NAUS)	268.0	211.0	220.7	266.3	261.6	209.7	215.6	258.2	234.7	201.8	204.8	238.3	268.8	211.6	219.8	266.6
(7) Pyrenee Mountains (PYRNES)	238.2	208.0	205.9	244.2	244.3	206.5	209.2	249.4	254.9	209.3	215.7	257.6	240.7	205.5	206.4	245.4
(8) Spokane, Washington (SPOK)	233.5	206.7	202.5	237.2	254.9	210.3	214.6	257.9	254.4	208.6	213.6	255.6	249.5	210.1	211.9	254.8
(9) Tehran, Iran (TEHRAN)	250.6	209.5	212.1	253.9	258.4	206.4	215.0	256.8	227.4	181.9	195.0	223.1	226.0	194.3	199.2	228.9
(10) Xining, China (XINING)	241.2	206.9	207.7	245.4	253.2	206.3	213.0	256.2	279.1	217.8	227.0	277.6	235.8	200.7	204.7	240.8
Elevation Angle = 3°																
	February 15th				May 15th				August 15th				November 15th			
	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	130.2	112.0	117.9	132.5	126.5	104.9	114.8	127.1	128.8	105.0	115.8	128.4	130.0	111.2	117.7	132.4
(2) Amazon Forest (AMFOR)	153.1	126.0	133.1	149.8	155.8	126.7	133.9	153.0	149.8	124.0	131.7	148.6	153.5	123.9	131.6	149.2
(3) Bangkok, Thailand (BANGK)	151.9	125.2	132.2	145.7	157.7	128.4	135.7	153.5	159.5	127.9	135.1	156.4	156.1	124.6	131.6	152.6
(4) Washington, D.C. (DC)	141.4	122.4	122.6	141.4	141.7	121.4	126.5	143.2	151.4	125.6	133.3	147.0	131.2	119.4	118.7	134.8
(5) Alaska (NAK)	132.0	121.3	119.2	137.2	134.5	122.0	120.7	138.6	139.6	122.1	123.2	142.1	131.7	120.8	119.4	135.5
(6) Northern Australia, Tanami Desert (NAUS)	147.8	120.7	128.2	146.2	145.9	121.0	125.6	143.2	133.0	117.9	120.3	135.4	148.4	121.3	127.7	146.4
(7) Pyrenee Mountains (PYRNES)	133.5	121.6	120.2	138.1	136.7	119.9	122.2	140.6	141.7	120.7	125.7	143.6	135.0	119.9	120.7	138.7
(8) Spokane, Washington (SPOK)	131.1	121.0	118.1	134.2	140.7	121.3	124.7	142.8	140.8	120.3	124.3	141.6	138.7	121.8	123.4	142.6
(9) Tehran, Iran (TEHRAN)	139.6	121.5	123.6	142.1	143.9	118.9	125.5	142.6	132.4	106.4	116.3	129.5	129.9	114.1	117.9	132.4
(10) Xining, China (XINING)	135.8	120.7	121.5	139.1	140.9	119.0	124.2	143.0	151.8	124.2	131.3	150.2	133.6	117.2	120.3	137.5
Elevation Angle = 5°																
	February 15th				May 15th				August 15th				November 15th			
	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	88.0	76.5	81.0	89.8	86.0	71.8	79.2	86.6	87.4	71.8	79.9	87.4	88.0	76.0	80.9	89.8
(2) Amazon Forest (AMFOR)	101.6	85.3	90.7	98.7	103.3	85.8	91.3	100.8	99.7	84.1	89.9	98.3	102.1	84.0	89.8	98.6
(3) Bangkok, Thailand (BANGK)	100.8	84.8	90.2	95.9	104.3	86.8	92.4	100.7	105.7	86.6	92.0	103.0	103.8	84.5	89.8	101.0
(4) Washington, D.C. (DC)	94.8	83.5	83.7	94.9	94.6	82.5	86.4	95.4	100.4	85.1	90.9	96.6	88.1	81.6	81.2	90.9
(5) Alaska (NAK)	88.5	82.9	81.4	92.4	90.2	83.3	82.4	93.2	93.5	83.2	84.1	95.3	88.4	82.6	81.6	91.2
(6) Northern Australia, Tanami Desert (NAUS)	98.7	81.9	87.6	97.2	97.6	82.3	85.8	95.7	89.6	80.5	82.4	91.3	99.0	82.4	87.2	97.4
(7) Pyrenee Mountains (PYRNES)	89.5	83.1	82.1	92.9	91.7	81.8	83.5	94.4	94.9	82.1	85.9	96.1	90.6	81.8	82.5	93.3
(8) Spokane, Washington (SPOK)	87.9	82.7	80.6	90.2	93.9	82.5	85.2	95.3	94.1	81.8	84.9	94.5	92.8	83.0	84.2	95.5
(9) Tehran, Iran (TEHRAN)	93.4	82.8	84.5	95.2	96.3	80.8	85.8	95.2	89.8	72.7	80.2	88.0	87.9	78.1	81.0	89.8
(10) Xining, China (XINING)	91.2	82.4	83.1	93.7	94.3	81.0	85.0	95.7	101.0	84.2	89.6	99.5	89.9	80.0	82.4	92.8
Elevation Angle = 10°																
	February 15th				May 15th				August 15th				November 15th			
	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	47.3	41.5	44.2	48.4	46.4	39.0	43.3	46.8	47.1	39.0	43.7	47.2	47.3	41.3	44.1	48.4
(2) Amazon Forest (AMFOR)	54.0	46.0	49.2	52.2	54.9	46.2	49.5	53.3	53.0	45.3	48.8	52.1	54.3	45.3	48.7	52.3
(3) Bangkok, Thailand (BANGK)	53.6	45.7	48.9	50.6	55.3	46.7	50.1	53.1	56.1	46.6	49.9	54.4	55.2	45.5	48.7	53.5
(4) Washington, D.C. (DC)	50.7	45.2	45.4	50.8	50.4	44.6	46.9	50.8	53.4	45.8	49.3	51.0	47.2	44.3	44.1	48.8
(5) Alaska (NAK)	47.4	45.0	44.1	49.5	48.2	45.2	44.7	50.0	50.0	45.1	45.6	51.0	47.3	44.8	44.3	49.0
(6) Northern Australia, Tanami Desert (NAUS)	52.6	44.2	47.6	51.7	52.2	44.5	46.6	51.0	48.1	43.7	44.8	49.0	52.8	44.5	47.4	51.8
(7) Pyrenee Mountains (PYRNES)	47.9	45.1	44.5	49.8	49.0	44.3	45.4	50.5	50.7	44.4	46.7	51.3	48.4	44.4	44.8	50.0
(8) Spokane, Washington (SPOK)	47.0	44.9	43.7	48.4	50.1	44.6	46.2	50.8	50.2	44.2	46.1	50.4	49.6	44.9	45.7	51.1
(9) Tehran, Iran (TEHRAN)	49.9	44.8	45.8	50.9	51.4	43.7	46.7	50.8	48.4	39.4	43.8	47.5	47.2	42.4	44.1	48.4
(10) Xining, China (XINING)	48.8	44.7	45.1	50.2	50.4	43.8	46.2	51.1	53.7	45.4	48.6	52.8	48.2	43.4	44.8	49.8

Angle Error (degrees) for 10 Selected Areas-of-Interest
MRF, Goad and Exponential Model
at 0000 Hours

AOI	February 15th MRF	February 15th Goad	February 15th Exp.	May 15th MRF	May 15th Goad	May 15th Exp.	August 15th MRF	August 15th Goad	August 15th Exp.	November 15th MRF	November 15th Goad	November 15th Exp.
Elevation Angle = 0°												
(1) Ahaggar, Algeria (AHAGR)	0.2701	0.5756	0.2635	0.2334	0.5020	0.2204	0.2542	0.5535	0.2437	0.2764	0.5816	0.2618
(2) Amazon Forest (AMFOR)	0.4807	0.9099	0.4489	0.5059	0.9436	0.4753	0.4824	0.8894	0.4265	0.4540	0.9021	0.4422
(3) Bangkok, Thailand (BANGK)	0.5054	0.9090	0.4623	0.4953	0.9389	0.4540	0.4914	0.9510	0.4533	0.4244	0.8960	0.4217
(4) Washington, D.C. (DC)	0.2672	0.5833	0.2724	0.4817	0.8483	0.4175	0.5401	0.9405	0.4825	0.2908	0.6344	0.2857
(5) Alaska (NAK)	0.3048	0.6169	0.2833	0.3124	0.6388	0.2946	0.3457	0.6860	0.3182	0.2881	0.6015	0.2797
(6) Northern Australia, Tanami Desert (NAUS)	0.4198	0.8229	0.3834	0.3042	0.6818	0.3207	0.2886	0.5957	0.2751	0.3370	0.7466	0.3497
(7) Pyrenee Mountains (PYRNES)	0.3096	0.6189	0.2914	0.3358	0.6776	0.3082	0.3706	0.7421	0.3414	0.3090	0.6329	0.2945
(8) Spokane, Washington (SPOK)	0.2731	0.5845	0.2762	0.3315	0.7008	0.3160	0.3093	0.6775	0.3047	0.3530	0.7275	0.3379
(9) Tehran, Iran (TEHRAN)	0.3372	0.6933	0.3157	0.3500	0.7377	0.3400	0.3134	0.6876	0.3146	0.2314	0.5225	0.2368
(10) Xining, China (XINING)	0.3003	0.6310	0.2956	0.3243	0.6746	0.3080	0.4893	0.9555	0.4580	0.2934	0.6193	0.2808
Elevation Angle = 1°												
(1) Ahaggar, Algeria (AHAGR)	0.2376	0.4225	0.2326	0.2024	0.3763	0.1968	0.2203	0.4058	0.2168	0.2396	0.4249	0.2312
(2) Amazon Forest (AMFOR)	0.3939	0.6179	0.3813	0.4108	0.6379	0.4015	0.3895	0.6056	0.3651	0.3813	0.6132	0.3768
(3) Bangkok, Thailand (BANGK)	0.4055	0.6173	0.3914	0.4067	0.6350	0.3877	0.4009	0.6422	0.3874	0.3638	0.6094	0.3629
(4) Washington, D.C. (DC)	0.2402	0.4301	0.2396	0.3853	0.5813	0.3573	0.4284	0.6363	0.4065	0.2595	0.4571	0.2549
(5) Alaska (NAK)	0.2623	0.4483	0.2494	0.2695	0.4608	0.2580	0.2912	0.4874	0.2776	0.2535	0.4390	0.2457
(6) Northern Australia, Tanami Desert (NAUS)	0.3476	0.5658	0.3328	0.2696	0.4831	0.2796	0.2530	0.4342	0.2420	0.2954	0.5210	0.3038
(7) Pyrenee Mountains (PYRNES)	0.2665	0.4498	0.2549	0.2851	0.4818	0.2697	0.3109	0.5190	0.2964	0.2680	0.4566	0.2579
(8) Spokane, Washington (SPOK)	0.2430	0.4317	0.2423	0.2901	0.4939	0.2781	0.2716	0.4802	0.2696	0.3019	0.5112	0.2932
(9) Tehran, Iran (TEHRAN)	0.2875	0.4912	0.2754	0.3015	0.5163	0.2958	0.2773	0.4852	0.2770	0.2069	0.3910	0.2103
(10) Xining, China (XINING)	0.2631	0.4575	0.2589	0.2808	0.4795	0.2692	0.4051	0.6449	0.3901	0.2566	0.4488	0.2471
Elevation Angle = 3°												
(1) Ahaggar, Algeria (AHAGR)	0.1506	0.2530	0.1481	0.1302	0.2292	0.1280	0.1414	0.2432	0.1403	0.1513	0.2536	0.1479
(2) Amazon Forest (AMFOR)	0.2322	0.3475	0.2327	0.2411	0.3573	0.2435	0.2281	0.3414	0.2246	0.2286	0.3452	0.2306
(3) Bangkok, Thailand (BANGK)	0.2355	0.3471	0.2376	0.2395	0.3558	0.2374	0.2381	0.3593	0.2376	0.2226	0.3432	0.2241
(4) Washington, D.C. (DC)	0.1537	0.2579	0.1516	0.2239	0.3296	0.2197	0.2466	0.3566	0.2461	0.1653	0.2696	0.1625
(5) Alaska (NAK)	0.1639	0.2659	0.1586	0.1683	0.2719	0.1632	0.1790	0.2844	0.1751	0.1604	0.2613	0.1560
(6) Northern Australia, Tanami Desert (NAUS)	0.2085	0.3217	0.2072	0.1724	0.2816	0.1761	0.1580	0.2586	0.1537	0.1866	0.3000	0.1904
(7) Pyrenee Mountains (PYRNES)	0.1660	0.2668	0.1610	0.1758	0.2814	0.1705	0.1894	0.2993	0.1860	0.1676	0.2696	0.1632
(8) Spokane, Washington (SPOK)	0.1558	0.2587	0.1535	0.1806	0.2867	0.1762	0.1724	0.2799	0.1716	0.1860	0.2958	0.1835
(9) Tehran, Iran (TEHRAN)	0.1775	0.2861	0.1734	0.1873	0.2979	0.1857	0.1750	0.2820	0.1759	0.1349	0.2375	0.1350
(10) Xining, China (XINING)	0.1649	0.2710	0.1624	0.1745	0.2801	0.1701	0.2411	0.3607	0.2389	0.1611	0.2660	0.1564
Elevation Angle = 5°												
(1) Ahaggar, Algeria (AHAGR)	0.1042	0.1747	0.1026	0.0909	0.1593	0.0893	0.0983	0.1682	0.0976	0.1046	0.1750	0.1026
(2) Amazon Forest (AMFOR)	0.1566	0.2349	0.1584	0.1624	0.2412	0.1654	0.1537	0.2310	0.1533	0.1547	0.2334	0.1571
(3) Bangkok, Thailand (BANGK)	0.1582	0.2347	0.1613	0.1614	0.2402	0.1617	0.1610	0.2425	0.1619	0.1515	0.2322	0.1531
(4) Washington, D.C. (DC)	0.1065	0.1780	0.1048	0.1506	0.2234	0.1499	0.1653	0.2408	0.1671	0.1141	0.1851	0.1122
(5) Alaska (NAK)	0.1128	0.1828	0.1096	0.1158	0.1867	0.1127	0.1227	0.1947	0.1207	0.1107	0.1799	0.1077
(6) Northern Australia, Tanami Desert (NAUS)	0.1413	0.2184	0.1419	0.1192	0.1929	0.1213	0.1087	0.1783	0.1064	0.1285	0.2045	0.1308
(7) Pyrenee Mountains (PYRNES)	0.1142	0.1835	0.1111	0.1205	0.1927	0.1176	0.1294	0.2042	0.1280	0.1153	0.1852	0.1127
(8) Spokane, Washington (SPOK)	0.1079	0.1784	0.1060	0.1238	0.1960	0.1215	0.1190	0.1917	0.1185	0.1273	0.2019	0.1261
(9) Tehran, Iran (TEHRAN)	0.1217	0.1958	0.1195	0.1284	0.2032	0.1277	0.1204	0.1930	0.1213	0.0944	0.1648	0.0938
(10) Xining, China (XINING)	0.1136	0.1864	0.1120	0.1198	0.1919	0.1174	0.1631	0.2434	0.1629	0.1112	0.1831	0.1082
Elevation Angle = 10°												
(1) Ahaggar, Algeria (AHAGR)	0.0564	0.0948	0.0555	0.0495	0.0869	0.0486	0.0534	0.0914	0.0530	0.0566	0.0950	0.0556
(2) Amazon Forest (AMFOR)	0.0832	0.1257	0.0846	0.0863	0.1289	0.0883	0.0817	0.1237	0.0821	0.0824	0.1249	0.0840
(3) Bangkok, Thailand (BANGK)	0.0839	0.1255	0.0861	0.0858	0.1284	0.0864	0.0858	0.1295	0.0866	0.0810	0.1242	0.0820
(4) Washington, D.C. (DC)	0.0577	0.0965	0.0567	0.0800	0.1197	0.0802	0.0876	0.1287	0.0891	0.0616	0.1000	0.0606
(5) Alaska (NAK)	0.0608	0.0989	0.0592	0.0625	0.1009	0.0608	0.0660	0.1050	0.0651	0.0598	0.0974	0.0582
(6) Northern Australia, Tanami Desert (NAUS)	0.0754	0.1172	0.0761	0.0644	0.1041	0.0654	0.0586	0.0966	0.0576	0.0692	0.1101	0.0704
(7) Pyrenee Mountains (PYRNES)	0.0615	0.0993	0.0600	0.0648	0.1040	0.0635	0.0694	0.1099	0.0689	0.0622	0.1001	0.0608
(8) Spokane, Washington (SPOK)	0.0584	0.0966	0.0572	0.0665	0.1057	0.0655	0.0643	0.1034	0.0640	0.0684	0.1087	0.0679
(9) Tehran, Iran (TEHRAN)	0.0655	0.1056	0.0644	0.0690	0.1094	0.0688	0.0649	0.1041	0.0655	0.0514	0.0897	0.0509
(10) Xining, China (XINING)	0.0613	0.1008	0.0604	0.0645	0.1036	0.0634	0.0869	0.1300	0.0871	0.0601	0.0991	0.0585

Angle Error (degrees) for 10 Selected Areas-of-Interest
MRF, Goad and Exponential Model
at 0600 Hours

AOI	Elevation Angle = 0°											
	February 15th			May 15th			August 15th			November 15th		
	MRF	Goad	Exp.	MRF	Goad	Exp.	MRF	Goad	Exp.	MRF	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	0.2912	0.5906	0.2709	0.2478	0.5179	0.2294	0.2851	0.5818	0.2597	0.2830	0.5878	0.2672
(2) Amazon Forest (AMFOR)	0.4786	0.9040	0.4453	0.4913	0.9312	0.4595	0.4875	0.8853	0.4275	0.4473	0.8902	0.4350
(3) Bangkok, Thailand (BANGK)	0.4467	0.8637	0.4301	0.5355	0.9578	0.4704	0.4900	0.9438	0.4519	0.4380	0.8936	0.4221
(4) Washington, D.C. (DC)	0.2660	0.5886	0.2737	0.4650	0.8218	0.4005	0.5402	0.9411	0.4885	0.2825	0.6161	0.2796
(5) Alaska (NAK)	0.3061	0.6201	0.2847	0.3137	0.6410	0.2960	0.3450	0.6926	0.3217	0.2839	0.5996	0.2808
(6) Northern Australia, Tanami Desert (NAUS)	0.3078	0.7295	0.3106	0.2765	0.6781	0.3051	0.2340	0.5401	0.2459	0.3005	0.7207	0.3250
(7) Pyrenee Mountains (PYRNES)	0.3089	0.6214	0.2912	0.3246	0.6776	0.3008	0.4329	0.8780	0.4293	0.3030	0.6336	0.2917
(8) Spokane, Washington (SPOK)	0.2875	0.6030	0.2861	0.3815	0.7822	0.3597	0.3368	0.7154	0.3269	0.3499	0.7189	0.3375
(9) Tehran, Iran (TEHRAN)	0.3385	0.6969	0.3198	0.3226	0.7054	0.3233	0.2581	0.6018	0.2636	0.2207	0.5144	0.2316
(10) Xining, China (XINING)	0.2857	0.6065	0.2739	0.2506	0.5606	0.2367	0.5081	0.9913	0.4905	0.2590	0.5606	0.2474
	Elevation Angle = 1°											
	February 15th			May 15th			August 15th			November 15th		
	MRF	Goad	Exp.	MRF	Goad	Exp.	MRF	Goad	Exp.	MRF	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	0.2528	0.4319	0.2386	0.2129	0.3867	0.2043	0.2401	0.4233	0.2300	0.2446	0.4293	0.2355
(2) Amazon Forest (AMFOR)	0.3918	0.6144	0.3784	0.4010	0.6305	0.3899	0.3913	0.6032	0.3657	0.3758	0.6061	0.3711
(3) Bangkok, Thailand (BANGK)	0.3723	0.5904	0.3666	0.4277	0.6462	0.4002	0.3995	0.6379	0.3863	0.3688	0.6080	0.3629
(4) Washington, D.C. (DC)	0.2398	0.4336	0.2408	0.3719	0.5658	0.3438	0.4280	0.6366	0.4102	0.2531	0.4468	0.2498
(5) Alaska (NAK)	0.2638	0.4501	0.2506	0.2704	0.4621	0.2590	0.2921	0.4912	0.2804	0.2518	0.4381	0.2462
(6) Northern Australia, Tanami Desert (NAUS)	0.2773	0.5095	0.2791	0.2527	0.4801	0.2674	0.2163	0.3989	0.2178	0.2728	0.5048	0.2863
(7) Pyrenee Mountains (PYRNES)	0.2662	0.4511	0.2547	0.2776	0.4816	0.2637	0.3674	0.5991	0.3661	0.2645	0.4566	0.2558
(8) Spokane, Washington (SPOK)	0.2532	0.4432	0.2501	0.3281	0.5422	0.3146	0.2938	0.5028	0.2890	0.3010	0.5063	0.2927
(9) Tehran, Iran (TEHRAN)	0.2895	0.4934	0.2786	0.2836	0.4964	0.2826	0.2330	0.4329	0.2368	0.2000	0.3852	0.2060
(10) Xining, China (XINING)	0.2486	0.4402	0.2412	0.2230	0.4091	0.2152	0.4219	0.6663	0.4163	0.2262	0.4117	0.2194
	Elevation Angle = 3°											
	February 15th			May 15th			August 15th			November 15th		
	MRF	Goad	Exp.	MRF	Goad	Exp.	MRF	Goad	Exp.	MRF	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	0.1573	0.2577	0.1516	0.1355	0.2346	0.1324	0.1506	0.2521	0.1480	0.1537	0.2561	0.1502
(2) Amazon Forest (AMFOR)	0.2310	0.3458	0.2311	0.2366	0.3537	0.2376	0.2285	0.3402	0.2248	0.2257	0.3417	0.2275
(3) Bangkok, Thailand (BANGK)	0.2220	0.3339	0.2245	0.2470	0.3613	0.2439	0.2371	0.3572	0.2369	0.2234	0.3425	0.2241
(4) Washington, D.C. (DC)	0.1540	0.2597	0.1524	0.2167	0.3220	0.2121	0.2464	0.3568	0.2475	0.1617	0.2647	0.1593
(5) Alaska (NAK)	0.1648	0.2667	0.1593	0.1687	0.2726	0.1637	0.1801	0.2862	0.1767	0.1599	0.2610	0.1561
(6) Northern Australia, Tanami Desert (NAUS)	0.1766	0.2936	0.1781	0.1652	0.2798	0.1696	0.1414	0.2403	0.1401	0.1765	0.2916	0.1814
(7) Pyrenee Mountains (PYRNES)	0.1659	0.2674	0.1609	0.1722	0.2813	0.1672	0.2223	0.3383	0.2247	0.1662	0.2695	0.1622
(8) Spokane, Washington (SPOK)	0.1608	0.2645	0.1579	0.2006	0.3103	0.1971	0.1838	0.2911	0.1827	0.1854	0.2935	0.1831
(9) Tehran, Iran (TEHRAN)	0.1789	0.2872	0.1751	0.1789	0.2878	0.1784	0.1513	0.2558	0.1530	0.1319	0.2343	0.1325
(10) Xining, China (XINING)	0.1573	0.2613	0.1536	0.1436	0.2443	0.1402	0.2507	0.3712	0.2529	0.1447	0.2468	0.1412
	Elevation Angle = 5°											
	February 15th			May 15th			August 15th			November 15th		
	MRF	Goad	Exp.	MRF	Goad	Exp.	MRF	Goad	Exp.	MRF	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	0.1082	0.1778	0.1050	0.0942	0.1628	0.0922	0.1041	0.1739	0.1027	0.1061	0.1766	0.1041
(2) Amazon Forest (AMFOR)	0.1558	0.2338	0.1573	0.1597	0.2389	0.1617	0.1539	0.2303	0.1534	0.1529	0.2312	0.1551
(3) Bangkok, Thailand (BANGK)	0.1501	0.2262	0.1529	0.1657	0.2437	0.1658	0.1603	0.2411	0.1614	0.1518	0.2317	0.1530
(4) Washington, D.C. (DC)	0.1068	0.1792	0.1054	0.1460	0.2186	0.1449	0.1652	0.2409	0.1679	0.1117	0.1820	0.1100
(5) Alaska (NAK)	0.1134	0.1834	0.1100	0.1161	0.1872	0.1130	0.1235	0.1958	0.1218	0.1105	0.1798	0.1078
(6) Northern Australia, Tanami Desert (NAUS)	0.1217	0.2004	0.1228	0.1148	0.1916	0.1171	0.0984	0.1665	0.0973	0.1222	0.1991	0.1249
(7) Pyrenee Mountains (PYRNES)	0.1141	0.1839	0.1110	0.1182	0.1926	0.1154	0.1509	0.2290	0.1533	0.1145	0.1851	0.1120
(8) Spokane, Washington (SPOK)	0.1112	0.1821	0.1089	0.1367	0.2111	0.1352	0.1261	0.1988	0.1258	0.1268	0.2005	0.1258
(9) Tehran, Iran (TEHRAN)	0.1227	0.1965	0.1206	0.1231	0.1968	0.1229	0.1051	0.1761	0.1062	0.0925	0.1627	0.0922
(10) Xining, China (XINING)	0.1087	0.1799	0.1063	0.0997	0.1688	0.0975	0.1693	0.2501	0.1718	0.1005	0.1706	0.0980
	Elevation Angle = 10°											
	February 15th			May 15th			August 15th			November 15th		
	MRF	Goad	Exp.	MRF	Goad	Exp.	MRF	Goad	Exp.	MRF	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	0.0583	0.0964	0.0568	0.0512	0.0887	0.0501	0.0563	0.0944	0.0557	0.0574	0.0958	0.0564
(2) Amazon Forest (AMFOR)	0.0828	0.1251	0.0841	0.0849	0.1277	0.0864	0.0818	0.1233	0.0821	0.0815	0.1238	0.0830
(3) Bangkok, Thailand (BANGK)	0.0799	0.1212	0.0818	0.0878	0.1302	0.0885	0.0854	0.1289	0.0863	0.0810	0.1240	0.0820
(4) Washington, D.C. (DC)	0.0579	0.0971	0.0570	0.0776	0.1173	0.0777	0.0876	0.1287	0.0895	0.0604	0.0984	0.0594
(5) Alaska (NAK)	0.0611	0.0992	0.0594	0.0626	0.1011	0.0610	0.0665	0.1056	0.0657	0.0597	0.0974	0.0583
(6) Northern Australia, Tanami Desert (NAUS)	0.0656	0.1079	0.0662	0.0622	0.1035	0.0632	0.0534	0.0906	0.0528	0.0660	0.1073	0.0673
(7) Pyrenee Mountains (PYRNES)	0.0615	0.0995	0.0599	0.0636	0.1039	0.0623	0.0806	0.1227	0.0820	0.0618	0.1001	0.0605
(8) Spokane, Washington (SPOK)	0.0601	0.0985	0.0588	0.0732	0.1134	0.0727	0.0679	0.1070	0.0678	0.0681	0.1080	0.0677
(9) Tehran, Iran (TEHRAN)	0.0660	0.1059	0.0650	0.0663	0.1061	0.0662	0.0570	0.0955	0.0575	0.0505	0.0887	0.0501
(10) Xining, China (XINING)	0.0588	0.0974	0.0575	0.0541	0.0917	0.0529	0.0901	0.1334	0.0917	0.0546	0.0927	0.0532

Angle Error (degrees) for 10 Selected Areas-of-Interest
MRF, Goad and Exponential
at 1200 Hours

Elevation Angle = 0°

AOI	February 15th MRF	February 15th Goad	February 15th Exp.	May 15th MRF	May 15th Goad	May 15th Exp.	August 15th MRF	August 15th Goad	August 15th Exp.	November 15th MRF	November 15th Goad	November 15th Exp.
(1) Ahaggar, Algeria (AHAGR)	0.2346	0.5311	0.2397	0.2001	0.4746	0.2044	0.2288	0.5278	0.2259	0.2277	0.5261	0.2330
(2) Amazon Forest (AMFOR)	0.4852	0.9029	0.4473	0.4976	0.9261	0.4545	0.4904	0.8862	0.4313	0.4498	0.8950	0.4386
(3) Bangkok, Thailand (BANGK)	0.4617	0.8850	0.4458	0.4995	0.9270	0.4495	0.4840	0.9362	0.4431	0.4255	0.8911	0.4205
(4) Washington, D.C. (DC)	0.2734	0.6193	0.2876	0.4458	0.7983	0.3823	0.5255	0.9307	0.4829	0.2830	0.6070	0.2791
(5) Alaska (NAK)	0.3072	0.6160	0.2824	0.3128	0.6379	0.2957	0.3462	0.6876	0.3202	0.2920	0.5989	0.2810
(6) Northern Australia, Tanami Desert (NAUS)	0.3496	0.7693	0.3343	0.3046	0.7115	0.3289	0.2701	0.5779	0.2647	0.3500	0.7653	0.3505
(7) Pyrenee Mountains (PYRNES)	0.3107	0.6193	0.2912	0.3187	0.6687	0.2962	0.3518	0.7341	0.3308	0.3055	0.6340	0.2930
(8) Spokane, Washington (SPOK)	0.2768	0.5945	0.2755	0.3336	0.7111	0.3208	0.3385	0.7140	0.3259	0.3418	0.7006	0.3240
(9) Tehran, Iran (TEHRAN)	0.3309	0.7020	0.3239	0.2980	0.6828	0.3058	0.1440	0.4327	0.1782	0.2101	0.5007	0.2237
(10) Xining, China (XINING)	0.2842	0.6053	0.2734	0.2797	0.6238	0.2636	0.4699	0.9326	0.4664	0.2698	0.5767	0.2571

Elevation Angle = 1°

AOI	February 15th MRF	February 15th Goad	February 15th Exp.	May 15th MRF	May 15th Goad	May 15th Exp.	August 15th MRF	August 15th Goad	August 15th Exp.	November 15th MRF	November 15th Goad	November 15th Exp.
(1) Ahaggar, Algeria (AHAGR)	0.2141	0.3939	0.2128	0.1804	0.3573	0.1836	0.2005	0.3889	0.2019	0.2067	0.3902	0.2073
(2) Amazon Forest (AMFOR)	0.3944	0.6138	0.3795	0.4024	0.6276	0.3858	0.3923	0.6038	0.3678	0.3768	0.6091	0.3732
(3) Bangkok, Thailand (BANGK)	0.3853	0.6029	0.3795	0.4077	0.6278	0.3851	0.3937	0.6334	0.3800	0.3631	0.6064	0.3623
(4) Washington, D.C. (DC)	0.2464	0.4511	0.2522	0.3560	0.5520	0.3293	0.4202	0.6304	0.4056	0.2511	0.4420	0.2472
(5) Alaska (NAK)	0.2635	0.4478	0.2487	0.2695	0.4606	0.2587	0.2921	0.4883	0.2790	0.2548	0.4382	0.2464
(6) Northern Australia, Tanami Desert (NAUS)	0.2990	0.5336	0.2952	0.2722	0.5008	0.2860	0.2401	0.4231	0.2334	0.3031	0.5317	0.3055
(7) Pyrenee Mountains (PYRNES)	0.2670	0.4498	0.2547	0.2730	0.4764	0.2599	0.2993	0.5142	0.2880	0.2662	0.4569	0.2568
(8) Spokane, Washington (SPOK)	0.2460	0.4368	0.2432	0.2927	0.5005	0.2832	0.2949	0.5022	0.2880	0.2957	0.4956	0.2820
(9) Tehran, Iran (TEHRAN)	0.2875	0.4959	0.2823	0.2648	0.4823	0.2697	0.1428	0.3300	0.1673	0.1922	0.3756	0.1993
(10) Xining, China (XINING)	0.2476	0.4399	0.2406	0.2492	0.4470	0.2398	0.3936	0.6314	0.3958	0.2355	0.4219	0.2274

Elevation Angle = 3°

AOI	February 15th MRF	February 15th Goad	February 15th Exp.	May 15th MRF	May 15th Goad	May 15th Exp.	August 15th MRF	August 15th Goad	August 15th Exp.	November 15th MRF	November 15th Goad	November 15th Exp.
(1) Ahaggar, Algeria (AHAGR)	0.1393	0.2380	0.1368	0.1201	0.2188	0.1203	0.1313	0.2342	0.1316	0.1355	0.2359	0.1341
(2) Amazon Forest (AMFOR)	0.2316	0.3456	0.2315	0.2362	0.3523	0.2354	0.2286	0.3406	0.2256	0.2262	0.3433	0.2284
(3) Bangkok, Thailand (BANGK)	0.2286	0.3400	0.2316	0.2387	0.3522	0.2361	0.2341	0.3550	0.2337	0.2218	0.3417	0.2239
(4) Washington, D.C. (DC)	0.1588	0.2680	0.1592	0.2089	0.3154	0.2042	0.2430	0.3538	0.2448	0.1600	0.2626	0.1575
(5) Alaska (NAK)	0.1642	0.2656	0.1582	0.1682	0.2720	0.1635	0.1795	0.2849	0.1757	0.1604	0.2612	0.1561
(6) Northern Australia, Tanami Desert (NAUS)	0.1862	0.3057	0.1869	0.1747	0.2903	0.1796	0.1521	0.2529	0.1490	0.1898	0.3051	0.1919
(7) Pyrenee Mountains (PYRNES)	0.1661	0.2668	0.1609	0.1697	0.2787	0.1650	0.1842	0.2969	0.1812	0.1670	0.2696	0.1627
(8) Spokane, Washington (SPOK)	0.1575	0.2609	0.1546	0.1825	0.2900	0.1793	0.1839	0.2909	0.1822	0.1820	0.2883	0.1772
(9) Tehran, Iran (TEHRAN)	0.1797	0.2882	0.1775	0.1700	0.2806	0.1716	0.1030	0.2042	0.1115	0.1279	0.2290	0.1289
(10) Xining, China (XINING)	0.1567	0.2613	0.1530	0.1586	0.2631	0.1550	0.2361	0.3541	0.2410	0.1496	0.2520	0.1457

Elevation Angle = 5°

AOI	February 15th MRF	February 15th Goad	February 15th Exp.	May 15th MRF	May 15th Goad	May 15th Exp.	August 15th MRF	August 15th Goad	August 15th Exp.	November 15th MRF	November 15th Goad	November 15th Exp.
(1) Ahaggar, Algeria (AHAGR)	0.0969	0.1650	0.0951	0.0845	0.1525	0.0841	0.0920	0.1624	0.0917	0.0946	0.1636	0.0933
(2) Amazon Forest (AMFOR)	0.1561	0.2337	0.1576	0.1592	0.2380	0.1602	0.1539	0.2305	0.1538	0.1532	0.2322	0.1556
(3) Bangkok, Thailand (BANGK)	0.1542	0.2301	0.1575	0.1605	0.2379	0.1608	0.1584	0.2397	0.1593	0.1509	0.2312	0.1529
(4) Washington, D.C. (DC)	0.1103	0.1844	0.1099	0.1411	0.2144	0.1398	0.1631	0.2390	0.1661	0.1106	0.1807	0.1088
(5) Alaska (NAK)	0.1129	0.1827	0.1093	0.1158	0.1868	0.1128	0.1231	0.1950	0.1211	0.1107	0.1800	0.1078
(6) Northern Australia, Tanami Desert (NAUS)	0.1277	0.2081	0.1287	0.1209	0.1984	0.1236	0.1050	0.1746	0.1033	0.1304	0.2078	0.1319
(7) Pyrenee Mountains (PYRNES)	0.1142	0.1835	0.1110	0.1167	0.1910	0.1139	0.1261	0.2026	0.1248	0.1149	0.1852	0.1123
(8) Spokane, Washington (SPOK)	0.1090	0.1797	0.1067	0.1251	0.1981	0.1235	0.1262	0.1986	0.1254	0.1245	0.1971	0.1220
(9) Tehran, Iran (TEHRAN)	0.1235	0.1971	0.1221	0.1177	0.1921	0.1184	0.0741	0.1430	0.0782	0.0899	0.1592	0.0897
(10) Xining, China (XINING)	0.1083	0.1800	0.1058	0.1096	0.1808	0.1075	0.1599	0.2391	0.1639	0.1037	0.1740	0.1010

Elevation Angle = 10°

AOI	February 15th MRF	February 15th Goad	February 15th Exp.	May 15th MRF	May 15th Goad	May 15th Exp.	August 15th MRF	August 15th Goad	August 15th Exp.	November 15th MRF	November 15th Goad	November 15th Exp.
(1) Ahaggar, Algeria (AHAGR)	0.0527	0.0899	0.0516	0.0463	0.0834	0.0458	0.0502	0.0885	0.0499	0.0515	0.0891	0.0507
(2) Amazon Forest (AMFOR)	0.0830	0.1250	0.0842	0.0846	0.1273	0.0856	0.0818	0.1234	0.0823	0.0817	0.1243	0.0833
(3) Bangkok, Thailand (BANGK)	0.0820	0.1232	0.0842	0.0852	0.1272	0.0859	0.0844	0.1281	0.0853	0.0807	0.1237	0.0819
(4) Washington, D.C. (DC)	0.0598	0.0998	0.0594	0.0752	0.1151	0.0750	0.0865	0.1277	0.0886	0.0598	0.0978	0.0588
(5) Alaska (NAK)	0.0609	0.0988	0.0590	0.0624	0.1009	0.0609	0.0662	0.1052	0.0653	0.0598	0.0975	0.0582
(6) Northern Australia, Tanami Desert (NAUS)	0.0687	0.1119	0.0693	0.0654	0.1070	0.0666	0.0568	0.0947	0.0559	0.0701	0.1117	0.0710
(7) Pyrenee Mountains (PYRNES)	0.0616	0.0993	0.0599	0.0628	0.1031	0.0615	0.0678	0.1091	0.0673	0.0620	0.1001	0.0607
(8) Spokane, Washington (SPOK)	0.0590	0.0972	0.0576	0.0672	0.1067	0.0665	0.0679	0.1070	0.0676	0.0668	0.1062	0.0657
(9) Tehran, Iran (TEHRAN)	0.0664	0.1062	0.0658	0.0636	0.1037	0.0639	0.0412	0.0785	0.0427	0.0491	0.0869	0.0488
(10) Xining, China (XINING)	0.0586	0.0975	0.0572	0.0593	0.0979	0.0582	0.0852	0.1278	0.0875	0.0562	0.0944	0.0548

Angle Error (degrees) **for 10 Selected Areas-of-Interest**
MRF, Goad and Exponential Model
at 1800 Hours

AOI	February 15th MRF	February 15th Goad	February 15th Exp.	May 15th MRF	May 15th Goad	May 15th Exp.	August 15th MRF	August 15th Goad	August 15th Exp.	November 15th MRF	November 15th Goad	November 15th Exp.
Elevation Angle = 0°												
(1) Ahaggar, Algeria (AHAGR)	0.2362	0.5330	0.2381	0.1940	0.4651	0.2000	0.1994	0.4878	0.2095	0.2409	0.5322	0.2356
(2) Amazon Forest (AMFOR)	0.4867	0.9144	0.4500	0.5010	0.9364	0.4601	0.5383	1.0088	0.5159	0.4200	0.8763	0.4225
(3) Bangkok, Thailand (BANGK)	0.4684	0.8946	0.4537	0.5437	0.9780	0.4955	0.5214	0.9648	0.4711	0.4208	0.8849	0.4193
(4) Washington, D.C. (DC)	0.2960	0.6689	0.3100	0.4073	0.7666	0.3647	0.5140	0.9090	0.4701	0.2829	0.5979	0.2760
(5) Alaska (NAK)	0.3113	0.6187	0.2843	0.3116	0.6397	0.2962	0.3468	0.6930	0.3235	0.2930	0.5995	0.2831
(6) Northern Australia, Tanami Desert (NAUS)	0.3978	0.8060	0.3655	0.3363	0.7359	0.3461	0.2930	0.6033	0.2790	0.3825	0.7932	0.3700
(7) Pyrenee Mountains (PYRNES)	0.3163	0.6260	0.2936	0.3299	0.6724	0.3043	0.3662	0.7391	0.3376	0.3086	0.6362	0.2953
(8) Spokane, Washington (SPOK)	0.2788	0.6130	0.2749	0.3634	0.7458	0.3441	0.3492	0.7386	0.3367	0.3449	0.7048	0.3232
(9) Tehran, Iran (TEHRAN)	0.3324	0.6989	0.3230	0.3370	0.7317	0.3413	0.1985	0.5122	0.2199	0.2403	0.5264	0.2387
(10) Xining, China (XINING)	0.3007	0.6339	0.2901	0.3457	0.7201	0.3258	0.4417	0.8648	0.4226	0.2841	0.6027	0.2723
Elevation Angle = 1°												
(1) Ahaggar, Algeria (AHAGR)	0.2122	0.3952	0.2114	0.1756	0.3517	0.1801	0.1809	0.3647	0.1884	0.2127	0.3942	0.2094
(2) Amazon Forest (AMFOR)	0.3965	0.6205	0.3822	0.4069	0.6336	0.3912	0.4418	0.6770	0.4325	0.3601	0.5978	0.3618
(3) Bangkok, Thailand (BANGK)	0.3878	0.6087	0.3845	0.4359	0.6583	0.4179	0.4157	0.6505	0.4001	0.3598	0.6028	0.3606
(4) Washington, D.C. (DC)	0.2648	0.4783	0.2705	0.3365	0.5331	0.3153	0.4132	0.6176	0.3961	0.2496	0.4365	0.2430
(5) Alaska (NAK)	0.2662	0.4494	0.2502	0.2691	0.4616	0.2591	0.2942	0.4916	0.2816	0.2557	0.4386	0.2479
(6) Northern Australia, Tanami Desert (NAUS)	0.3312	0.5556	0.3206	0.2934	0.5155	0.2998	0.2558	0.4387	0.2450	0.3250	0.5484	0.3213
(7) Pyrenee Mountains (PYRNES)	0.2704	0.4537	0.2568	0.2813	0.4786	0.2666	0.3081	0.5172	0.2934	0.2683	0.4583	0.2586
(8) Spokane, Washington (SPOK)	0.2514	0.4458	0.2478	0.3147	0.5208	0.3016	0.3071	0.5162	0.2994	0.2973	0.4979	0.2817
(9) Tehran, Iran (TEHRAN)	0.2885	0.4946	0.2812	0.2950	0.5121	0.2968	0.1844	0.3795	0.1992	0.2141	0.3932	0.2120
(10) Xining, China (XINING)	0.2614	0.4578	0.2543	0.2987	0.5052	0.2862	0.3707	0.5913	0.3606	0.2487	0.4379	0.2398
Elevation Angle = 3°												
(1) Ahaggar, Algeria (AHAGR)	0.1378	0.2387	0.1361	0.1174	0.2160	0.1184	0.1216	0.2222	0.1235	0.1373	0.2380	0.1352
(2) Amazon Forest (AMFOR)	0.2329	0.3488	0.2332	0.2389	0.3551	0.2387	0.2585	0.3766	0.2603	0.2195	0.3376	0.2227
(3) Bangkok, Thailand (BANGK)	0.2298	0.3429	0.2339	0.2521	0.3673	0.2526	0.2436	0.3635	0.2439	0.2201	0.3400	0.2227
(4) Washington, D.C. (DC)	0.1691	0.2805	0.1700	0.2009	0.3060	0.1964	0.2392	0.3474	0.2399	0.1585	0.2599	0.1547
(5) Alaska (NAK)	0.1653	0.2664	0.1590	0.1682	0.2724	0.1637	0.1809	0.2865	0.1771	0.1607	0.2615	0.1568
(6) Northern Australia, Tanami Desert (NAUS)	0.2013	0.3166	0.2011	0.1845	0.2977	0.1874	0.1594	0.2608	0.1556	0.1999	0.3133	0.2007
(7) Pyrenee Mountains (PYRNES)	0.1676	0.2687	0.1621	0.1739	0.2798	0.1688	0.1880	0.2984	0.1843	0.1679	0.2703	0.1637
(8) Spokane, Washington (SPOK)	0.1608	0.2645	0.1581	0.1933	0.2999	0.1895	0.1908	0.2974	0.1889	0.1829	0.2893	0.1774
(9) Tehran, Iran (TEHRAN)	0.1796	0.2878	0.1765	0.1851	0.2956	0.1863	0.1254	0.2295	0.1305	0.1379	0.2386	0.1360
(10) Xining, China (XINING)	0.1640	0.2705	0.1605	0.1847	0.2922	0.1809	0.2223	0.3345	0.2216	0.1569	0.2602	0.1527
Elevation Angle = 5°												
(1) Ahaggar, Algeria (AHAGR)	0.0961	0.1655	0.0946	0.0828	0.1507	0.0827	0.0857	0.1547	0.0863	0.0956	0.1650	0.0941
(2) Amazon Forest (AMFOR)	0.1569	0.2358	0.1587	0.1610	0.2398	0.1624	0.1737	0.2536	0.1764	0.1492	0.2286	0.1519
(3) Bangkok, Thailand (BANGK)	0.1551	0.2320	0.1590	0.1690	0.2476	0.1713	0.1642	0.2451	0.1659	0.1499	0.2301	0.1521
(4) Washington, D.C. (DC)	0.1170	0.1923	0.1172	0.1362	0.2084	0.1347	0.1606	0.2349	0.1630	0.1095	0.1790	0.1069
(5) Alaska (NAK)	0.1136	0.1832	0.1098	0.1158	0.1871	0.1130	0.1240	0.1960	0.1220	0.1109	0.1801	0.1083
(6) Northern Australia, Tanami Desert (NAUS)	0.1371	0.2151	0.1379	0.1269	0.2031	0.1288	0.1096	0.1797	0.1077	0.1365	0.2130	0.1376
(7) Pyrenee Mountains (PYRNES)	0.1151	0.1847	0.1118	0.1193	0.1917	0.1165	0.1284	0.2036	0.1268	0.1156	0.1857	0.1130
(8) Spokane, Washington (SPOK)	0.1111	0.1819	0.1091	0.1319	0.2044	0.1301	0.1305	0.2028	0.1298	0.1251	0.1978	0.1221
(9) Tehran, Iran (TEHRAN)	0.1233	0.1969	0.1215	0.1272	0.2017	0.1281	0.0887	0.1593	0.0911	0.0961	0.1655	0.0945
(10) Xining, China (XINING)	0.1131	0.1859	0.1108	0.1263	0.1995	0.1246	0.1506	0.2267	0.1514	0.1084	0.1793	0.1057
Elevation Angle = 10°												
(1) Ahaggar, Algeria (AHAGR)	0.0522	0.0901	0.0514	0.0454	0.0825	0.0451	0.0470	0.0845	0.0470	0.0520	0.0898	0.0511
(2) Amazon Forest (AMFOR)	0.0834	0.1261	0.0848	0.0855	0.1282	0.0867	0.0921	0.1353	0.0940	0.0797	0.1224	0.0813
(3) Bangkok, Thailand (BANGK)	0.0825	0.1242	0.0849	0.0896	0.1322	0.0913	0.0873	0.1309	0.0886	0.0801	0.1232	0.0815
(4) Washington, D.C. (DC)	0.0632	0.1038	0.0632	0.0727	0.1120	0.0723	0.0852	0.1257	0.0870	0.0592	0.0970	0.0578
(5) Alaska (NAK)	0.0612	0.0991	0.0593	0.0625	0.1011	0.0610	0.0667	0.1057	0.0658	0.0599	0.0975	0.0585
(6) Northern Australia, Tanami Desert (NAUS)	0.0734	0.1155	0.0741	0.0684	0.1094	0.0693	0.0591	0.0973	0.0583	0.0732	0.1144	0.0739
(7) Pyrenee Mountains (PYRNES)	0.0620	0.0999	0.0604	0.0642	0.1035	0.0629	0.0689	0.1096	0.0683	0.0623	0.1004	0.0610
(8) Spokane, Washington (SPOK)	0.0601	0.0983	0.0589	0.0706	0.1100	0.0700	0.0701	0.1091	0.0699	0.0671	0.1066	0.0658
(9) Tehran, Iran (TEHRAN)	0.0663	0.1061	0.0654	0.0684	0.1086	0.0689	0.0487	0.0868	0.0496	0.0522	0.0901	0.0513
(10) Xining, China (XINING)	0.0611	0.1005	0.0598	0.0678	0.1074	0.0672	0.0804	0.1214	0.0811	0.0586	0.0971	0.0572

Appendix I

TIME DELAYS AND ANGLE ERRORS FOR SEASON AND MODELS/ANGLES BY HOURS

Time delays and angle errors are compared for 10 areas of interest with seasons and models by hours from the horizon to 10° from the horizon.

Time Delay (ns) for Selected Areas-of-Interest
MRF, Hopfield, Goad and Exponential Model for 15 February 1995
(0000, 0600, 1200 and 1800 Hours)

AOI	Elevation Angle = 0°															
	MRF				Hopfield				Goad				Exponential			
	0000	0600	1200	1800	0000	0600	1200	1800	0000	0600	1200	1800	0000	0600	1200	1800
(1) Ahaggar, Algeria (AHAGR)	334.0	334.0	334.0	334.0	284.9	288.8	271.8	272.6	288.8	291.1	280.8	280.9	336.3	341.4	325.1	324.2
(2) Amazon Forest (AMFOR)	431.7	430.3	430.9	431.5	330.0	329.6	329.7	330.1	338.6	337.4	337.5	339.5	424.6	423.6	423.7	424.0
(3) Bangkok, Thailand (BANGK)	430.0	415.8	421.9	425.6	329.3	321.6	325.1	326.9	338.2	331.5	334.3	336.2	418.8	408.7	413.9	416.4
(4) Washington, D.C. (DC)	337.2	340.3	350.3	362.3	294.1	295.8	299.6	302.8	291.3	292.2	296.2	302.5	341.0	343.7	351.9	363.1
(5) Alaska (NAK)	342.2	342.7	341.4	342.1	296.1	296.5	295.9	296.5	292.8	293.1	292.6	293.0	347.1	347.8	346.8	347.7
(6) Northern Australia, Tanami Desert (NAUS)	400.4	368.7	382.0	397.3	313.8	295.7	303.7	311.2	324.5	309.3	316.0	321.3	395.8	366.8	378.7	392.4
(7) Pyrenee Mountains (PYRNES)	345.1	345.1	345.5	346.8	297.1	297.2	296.6	297.7	294.2	294.6	294.4	295.3	349.8	350.1	350.4	351.7
(8) Spokane, Washington (SPOK)	333.3	338.6	334.7	337.1	296.3	301.1	296.5	295.3	289.3	292.4	289.6	290.7	337.4	343.0	339.1	340.7
(9) Tehran, Iran (TEHRAN)	364.4	365.6	366.3	365.7	302.5	303.2	302.6	303.5	305.0	305.6	305.8	306.0	367.2	368.4	368.5	368.7
(10) Xining, China (XINING)	348.3	339.4	339.9	348.7	300.3	288.8	289.6	297.0	298.5	291.8	292.2	297.6	351.3	343.3	344.0	352.5

	Elevation Angle = 1°															
	MRF				Hopfield				Goad				Exponential			
	0000	0600	1200	1800	0000	0600	1200	1800	0000	0600	1200	1800	0000	0600	1200	1800
(1) Ahaggar, Algeria (AHAGR)	233.0	233.2	226.5	226.7	199.4	201.9	190.4	191.0	203.1	204.3	198.9	198.9	235.9	239.1	229.9	229.4
(2) Amazon Forest (AMFOR)	284.7	283.9	283.8	283.9	221.9	221.9	222.0	221.8	230.4	229.7	229.8	231.0	281.0	280.7	280.7	280.4
(3) Bangkok, Thailand (BANGK)	280.9	276.5	279.3	281.3	221.3	216.9	218.9	220.0	230.2	226.6	228.0	229.1	274.7	271.1	273.1	274.0
(4) Washington, D.C. (DC)	235.5	237.9	244.6	251.4	206.6	207.8	209.7	210.2	204.2	204.6	206.7	210.2	238.6	240.6	245.3	251.2
(5) Alaska (NAK)	235.8	236.0	235.0	235.2	207.1	207.3	206.9	207.3	204.1	204.3	204.1	204.3	241.7	242.0	241.6	242.1
(6) Northern Australia, Tanami Desert (NAUS)	268.2	255.1	261.4	268.0	212.3	201.4	206.2	211.0	222.7	214.3	218.0	220.7	266.9	253.1	259.6	266.3
(7) Pyrenee Mountains (PYRNES)	237.4	237.6	237.7	238.2	207.8	207.7	207.3	208.0	205.2	205.5	205.4	205.9	243.0	243.2	243.5	244.2
(8) Spokane, Washington (SPOK)	231.4	234.2	232.1	233.5	208.6	211.7	208.4	206.7	202.1	203.8	202.1	202.5	235.1	238.4	236.2	237.2
(9) Tehran, Iran (TEHRAN)	249.5	250.3	251.1	250.6	209.0	209.4	208.6	209.5	211.5	211.9	211.9	212.1	253.6	254.1	253.5	253.9
(10) Xining, China (XINING)	240.9	235.6	236.1	241.2	209.7	201.4	202.0	206.9	208.3	204.3	204.6	207.7	244.0	240.0	240.6	245.4

	Elevation Angle = 3°															
	MRF				Hopfield				Goad				Exponential			
	0000	0600	1200	1800	0000	0600	1200	1800	0000	0600	1200	1800	0000	0600	1200	1800
(1) Ahaggar, Algeria (AHAGR)	132.7	132.1	130.0	130.2	116.7	118.1	111.6	112.0	119.6	120.0	118.0	117.9	135.0	136.5	132.8	132.5
(2) Amazon Forest (AMFOR)	153.6	153.3	153.1	153.1	126.1	126.3	126.3	126.0	132.8	132.4	132.5	133.1	150.2	150.3	150.2	149.8
(3) Bangkok, Thailand (BANGK)	150.9	150.1	150.9	151.9	125.8	123.6	124.6	125.2	132.7	131.1	131.7	132.2	145.5	145.4	145.4	145.7
(4) Washington, D.C. (DC)	133.5	135.0	138.4	141.4	121.3	122.0	122.8	122.4	119.6	119.7	120.7	122.6	136.2	137.3	139.2	141.4
(5) Alaska (NAK)	132.5	132.5	132.0	132.0	121.2	121.3	121.1	121.3	119.2	119.2	119.1	119.2	137.1	137.2	137.1	137.2
(6) Northern Australia, Tanami Desert (NAUS)	147.0	143.1	145.7	147.8	121.3	115.6	118.1	120.7	129.2	125.4	127.1	128.2	145.6	141.4	144.2	146.2
(7) Pyrenee Mountains (PYRNES)	133.2	133.3	133.3	133.5	121.6	121.5	121.3	121.6	119.8	120.0	120.0	120.2	137.5	137.7	137.8	138.1
(8) Spokane, Washington (SPOK)	130.5	131.5	130.6	131.1	122.6	124.4	122.4	121.0	118.0	118.7	117.8	118.1	133.5	135.0	134.1	134.2
(9) Tehran, Iran (TEHRAN)	139.3	139.6	139.9	139.6	121.2	121.4	120.8	121.5	123.3	123.5	123.5	123.6	142.4	142.5	141.7	142.1
(10) Xining, China (XINING)	135.5	133.2	133.6	135.8	122.6	117.6	118.0	120.7	121.7	119.9	120.1	121.5	137.9	136.7	137.2	139.1

	Elevation Angle = 5°															
	MRF				Hopfield				Goad				Exponential			
	0000	0600	1200	1800	0000	0600	1200	1800	0000	0600	1200	1800	0000	0600	1200	1800
(1) Ahaggar, Algeria (AHAGR)	89.5	89.0	87.8	88.0	79.8	80.7	76.3	76.5	82.0	82.2	81.1	81.0	91.2	92.1	90.0	89.8
(2) Amazon Forest (AMFOR)	101.9	101.8	101.7	101.6	85.5	85.6	85.6	85.3	90.5	90.2	90.3	90.7	99.1	99.2	99.1	98.7
(3) Bangkok, Thailand (BANGK)	100.1	99.8	100.2	100.8	85.2	83.8	84.5	84.8	90.4	89.5	89.8	90.2	95.6	96.0	95.8	95.9
(4) Washington, D.C. (DC)	89.8	90.8	93.0	94.8	83.0	83.5	83.9	83.5	81.7	81.8	82.4	83.7	91.9	92.6	93.8	94.9
(5) Alaska (NAK)	88.9	88.9	88.6	88.5	82.8	82.9	82.8	82.9	81.4	81.4	81.3	81.4	92.3	92.3	92.3	92.4
(6) Northern Australia, Tanami Desert (NAUS)	98.0	95.9	97.6	98.7	82.3	78.5	80.2	81.9	88.3	85.9	87.0	87.6	96.6	94.6	96.3	97.2
(7) Pyrenee Mountains (PYRNES)	89.3	89.4	89.4	89.5	83.1	83.0	82.9	83.1	81.8	82.0	82.0	82.1	92.5	92.6	92.7	92.9
(8) Spokane, Washington (SPOK)	87.5	88.2	87.6	87.9	83.9	85.1	83.7	82.7	80.5	80.9	80.4	80.6	90.0	90.9	90.3	90.2
(9) Tehran, Iran (TEHRAN)	93.3	93.5	93.6	93.4	82.6	82.8	82.3	82.8	84.3	84.4	84.4	84.5	95.5	95.5	94.9	95.2
(10) Xining, China (XINING)	90.9	89.6	89.8	91.2	83.8	80.3	80.6	82.4	83.1	82.1	82.2	83.1	92.8	92.2	92.6	93.7

	Elevation Angle = 10°															
	MRF				Hopfield				Goad				Exponential			
	0000	0600	1200	1800	0000	0600	1200	1800	0000	0600	1200	1800	0000	0600	1200	1800
(1) Ahaggar, Algeria (AHAGR)	48.0	47.7	47.2	47.3	43.3	43.8	41.4	41.5	44.6	44.7	44.2	44.2	49.0	49.5	48.5	48.4
(2) Amazon Forest (AMFOR)	54.2	54.1	54.0	54.0	46.0	46.1	46.1	46.0	49.1	48.9	49.0	49.2	52.4	52.4	52.4	52.2
(3) Bangkok, Thailand (BANGK)	53.2	53.1	53.3	53.6	45.9	45.2	45.5	45.7	49.0	48.6	48.7	48.9	50.5	50.8	50.6	50.6
(4) Washington, D.C. (DC)	48.1	48.7	49.8	50.7	45.1	45.3	45.5	45.2	44.4	44.4	44.7	45.4	49.3	49.7	50.3	50.8
(5) Alaska (NAK)	47.6	47.6	47.4	47.4	44.9	45.0	44.9	45.0	44.1	44.1	44.1	44.1	49.5	49.5	49.5	49.5
(6) Northern Australia, Tanami Desert (NAUS)	52.3	51.3	52.1	52.6	44.4	42.4	43.3	44.2	48.0	46.8	47.3	47.6	51.3	50.5	51.3	51.7
(7) Pyrenee Mountains (PYRNES)	47.8	47.8	47.8	47.9	45.1	45.0	45.0	45.1	44.4	44.5	44.5	44.5	49.6	49.6	49.7	49.8
(8) Spokane, Washington (SPOK)	46.8	47.1	46.8	47.0	45.6	46.2	45.5	44.9	43.6	43.8	43.5	43.7	48.3	48.7	48.4	48.4
(9) Tehran, Iran (TEHRAN)	49.9	49.9	50.0	49.9	44.7	44.8	44.6	44.8	45.7	45.8	45.8	45.8	51.1	51.1	50.7	50.9
(10) Xining, China (XINING)	48.7	48.0	48.1	48.8	45.4	43.5	43.7	44.7	45.1	44.6	44.7	45.1	49.7	49.5	49.7	50.2

Time Delay (ns) for Selected Areas-of-Interest
MRF, Hopfield, Goad and Exponential Model for 15 May 1995
(0000, 0600, 1200 and 1800 Hours)

AOI	Elevation Angle = 0°															
	MRF				Hopfield				Goad				Exponential			
	0000	0600	1200	1800	0000	0600	1200	1800	0000	0600	1200	1800	0000	0600	1200	1800
(1) Ahaggar, Algeria (AHAGR)	334.0	334.0	334.0	334.0	266.3	271.2	255.2	253.8	275.2	278.2	269.6	267.7	315.5	320.7	305.8	302.5
(2) Amazon Forest (AMFOR)	444.9	440.5	439.6	441.8	335.2	333.7	333.1	333.3	343.9	341.7	341.2	342.7	435.3	432.8	432.5	434.2
(3) Bangkok, Thailand (BANGK)	442.8	448.9	437.9	456.8	333.4	336.3	330.9	339.8	343.0	346.0	341.0	349.3	437.5	440.7	431.9	446.2
(4) Washington, D.C. (DC)	411.7	402.3	395.4	384.5	321.9	318.7	315.6	309.1	328.0	323.7	320.2	315.7	406.5	397.9	391.8	383.9
(5) Alaska (NAK)	347.5	348.2	348.0	348.4	298.7	299.1	299.3	299.5	296.7	297.1	296.9	297.1	352.6	353.1	352.6	353.0
(6) Northern Australia, Tanami Desert (NAUS)	368.3	361.0	372.2	380.7	295.7	292.4	300.5	305.9	303.4	302.3	308.3	311.8	365.4	358.6	368.8	377.8
(7) Pyrenee Mountains (PYRNES)	358.1	354.3	352.0	356.3	299.7	299.0	297.6	298.4	302.0	301.9	300.6	301.1	361.7	358.1	355.8	360.1
(8) Spokane, Washington (SPOK)	364.5	387.8	366.9	375.7	298.3	312.5	302.1	306.9	304.7	316.6	305.6	311.1	368.2	389.0	369.4	377.8
(9) Tehran, Iran (TEHRAN)	378.2	368.8	362.8	376.8	305.5	297.1	290.9	301.7	311.2	306.4	302.4	310.6	378.8	369.4	361.8	375.5
(10) Xining, China (XINING)	358.7	325.0	343.1	370.6	296.9	270.4	281.4	300.8	302.2	281.9	291.8	307.6	362.4	328.5	346.3	372.6
	Elevation Angle = 1°															
	MRF				Hopfield				Goad				Exponential			
	0000	0600	1200	1800	0000	0600	1200	1800	0000	0600	1200	1800	0000	0600	1200	1800
(1) Ahaggar, Algeria (AHAGR)	221.7	223.9	218.0	216.6	187.2	190.6	179.3	178.5	195.6	197.1	192.7	191.6	224.7	227.8	218.9	216.7
(2) Amazon Forest (AMFOR)	291.6	290.0	288.8	289.9	224.7	224.1	223.8	223.4	233.4	232.0	231.9	232.7	285.9	286.0	286.5	286.9
(3) Bangkok, Thailand (BANGK)	291.3	291.4	287.3	296.1	223.4	224.9	221.8	226.9	232.9	234.5	231.8	236.4	290.2	290.4	286.3	291.4
(4) Washington, D.C. (DC)	270.3	265.2	262.1	257.8	218.1	216.7	215.2	211.1	224.3	221.8	219.8	217.6	271.1	266.6	264.3	260.4
(5) Alaska (NAK)	239.1	239.5	239.5	239.8	208.2	208.4	208.8	208.8	206.5	206.8	206.7	206.9	244.9	245.1	244.9	245.1
(6) Northern Australia, Tanami Desert (NAUS)	255.4	252.1	258.1	261.6	203.6	201.0	206.3	209.7	211.1	210.5	213.8	215.6	251.6	248.0	253.3	258.2
(7) Pyrenee Mountains (PYRNES)	245.1	243.3	242.1	244.3	207.3	206.8	205.9	206.5	209.7	209.7	209.0	209.2	250.2	248.3	247.1	249.4
(8) Spokane, Washington (SPOK)	249.9	262.2	251.3	254.9	205.0	213.3	207.9	210.3	211.3	217.6	211.5	214.6	254.0	264.7	254.2	257.9
(9) Tehran, Iran (TEHRAN)	258.3	253.8	251.6	258.4	209.4	203.7	199.6	206.4	215.0	212.7	210.5	215.0	259.6	254.2	250.3	256.8
(10) Xining, China (XINING)	246.5	228.2	238.9	253.2	205.0	188.1	194.4	206.3	210.2	199.0	204.3	213.0	250.9	232.3	242.9	256.2
	Elevation Angle = 3°															
	MRF				Hopfield				Goad				Exponential			
	0000	0600	1200	1800	0000	0600	1200	1800	0000	0600	1200	1800	0000	0600	1200	1800
(1) Ahaggar, Algeria (AHAGR)	128.4	129.1	127.1	126.5	109.9	111.9	105.2	104.9	116.3	116.9	115.4	114.8	130.8	132.1	128.2	127.1
(2) Amazon Forest (AMFOR)	156.5	156.2	155.6	155.8	127.4	127.3	127.2	126.7	134.2	133.5	133.5	133.9	151.6	152.6	153.3	153.0
(3) Bangkok, Thailand (BANGK)	156.6	155.6	154.4	157.7	126.7	127.4	125.8	128.4	134.0	134.8	133.5	135.7	155.3	154.4	153.1	153.5
(4) Washington, D.C. (DC)	146.2	144.1	143.2	141.7	124.7	124.2	123.6	121.4	129.6	128.4	127.4	126.5	146.3	144.6	144.4	143.2
(5) Alaska (NAK)	134.0	134.2	134.3	134.5	121.6	121.7	122.0	122.0	120.5	120.7	120.6	120.7	138.6	138.6	138.5	138.6
(6) Northern Australia, Tanami Desert (NAUS)	143.7	142.5	145.0	145.9	117.8	116.2	119.1	121.0	123.6	123.5	124.9	125.6	140.8	139.5	141.3	143.2
(7) Pyrenee Mountains (PYRNES)	137.0	136.3	135.9	136.7	120.4	120.0	119.6	119.9	122.4	122.4	122.1	122.2	140.8	140.1	139.7	140.6
(8) Spokane, Washington (SPOK)	139.3	144.2	139.9	140.7	118.5	122.7	120.3	121.3	123.4	126.2	123.2	124.7	142.3	145.8	142.0	142.8
(9) Tehran, Iran (TEHRAN)	143.6	141.9	141.6	143.9	120.8	117.5	115.2	118.9	125.2	124.4	123.5	125.5	144.4	142.2	140.7	142.6
(10) Xining, China (XINING)	138.1	130.6	135.4	140.9	118.9	109.6	112.8	119.0	122.9	117.9	120.3	124.2	141.3	133.9	138.5	143.0
	Elevation Angle = 5°															
	MRF				Hopfield				Goad				Exponential			
	0000	0600	1200	1800	0000	0600	1200	1800	0000	0600	1200	1800	0000	0600	1200	1800
(1) Ahaggar, Algeria (AHAGR)	87.0	87.4	86.4	86.0	75.2	76.6	72.0	71.8	80.0	80.3	79.6	79.2	89.0	89.7	87.4	86.6
(2) Amazon Forest (AMFOR)	103.7	103.6	103.2	103.3	86.3	86.2	86.1	85.8	91.4	90.9	90.9	91.3	99.7	100.6	101.1	100.8
(3) Bangkok, Thailand (BANGK)	103.8	103.0	102.4	104.3	85.8	86.2	85.2	86.8	91.3	91.8	91.0	92.4	102.4	101.6	101.0	100.7
(4) Washington, D.C. (DC)	97.2	95.9	95.5	94.6	84.7	84.4	84.0	82.5	88.4	87.5	86.9	86.4	96.7	95.8	95.9	95.4
(5) Alaska (NAK)	89.9	90.0	90.0	90.2	83.1	83.1	83.3	83.3	82.3	82.4	82.3	82.4	93.2	93.2	93.2	93.2
(6) Northern Australia, Tanami Desert (NAUS)	96.4	95.7	97.2	97.6	80.3	79.1	81.1	82.3	84.6	84.6	85.5	85.8	94.4	93.6	94.6	95.7
(7) Pyrenee Mountains (PYRNES)	91.8	91.4	91.2	91.7	82.1	81.8	81.6	81.8	83.6	83.7	83.5	83.5	94.5	94.1	93.9	94.4
(8) Spokane, Washington (SPOK)	93.3	96.2	93.6	93.9	80.7	83.4	81.9	82.5	84.4	86.1	84.2	85.2	95.4	97.2	95.0	95.3
(9) Tehran, Iran (TEHRAN)	96.0	95.0	95.0	96.3	82.2	80.0	78.4	80.8	85.6	85.2	84.7	85.8	96.6	95.2	94.4	95.2
(10) Xining, China (XINING)	92.6	88.2	91.1	94.3	81.0	74.9	76.9	81.0	84.1	81.1	82.6	85.0	94.9	90.7	93.4	95.7
	Elevation Angle = 10°															
	MRF				Hopfield				Goad				Exponential			
	0000	0600	1200	1800	0000	0600	1200	1800	0000	0600	1200	1800	0000	0600	1200	1800
(1) Ahaggar, Algeria (AHAGR)	46.9	47.1	46.6	46.4	40.8	41.6	39.1	39.0	43.7	43.8	43.6	43.3	48.0	48.4	47.2	46.8
(2) Amazon Forest (AMFOR)	55.1	55.0	54.8	54.9	46.5	46.4	46.4	46.2	49.6	49.3	49.3	49.5	52.6	53.2	53.5	53.3
(3) Bangkok, Thailand (BANGK)	55.1	54.7	54.4	55.3	46.2	46.4	45.9	46.7	49.5	49.8	49.3	50.1	54.2	53.6	53.4	53.1
(4) Washington, D.C. (DC)	51.7	51.1	50.9	50.4	45.7	45.6	45.4	44.6	47.9	47.5	47.1	46.9	51.3	50.8	51.0	50.8
(5) Alaska (NAK)	48.0	48.1	48.1	48.2	45.0	45.1	45.2	45.2	44.6	44.7	44.7	44.7	50.0	50.0	49.9	50.0
(6) Northern Australia, Tanami Desert (NAUS)	51.6	51.2	52.0	52.2	43.4	42.8	43.8	44.5	46.0	46.1	46.5	46.6	50.4	50.1	50.5	51.0
(7) Pyrenee Mountains (PYRNES)	49.1	48.9	48.8	49.0	44.4	44.3	44.2	44.3	45.4	45.4	45.3	45.4	50.6	50.4	50.3	50.5
(8) Spokane, Washington (SPOK)	49.8	51.2	50.0	50.1	43.7	45.1	44.3	44.6	45.9	46.7	45.7	46.2	51.0	51.7	50.8	50.8
(9) Tehran, Iran (TEHRAN)	51.2	50.8	50.8	51.4	44.4	43.3	42.4	43.7	46.5	46.3	46.1	46.7	51.5	50.9	50.5	50.8
(10) Xining, China (XINING)	49.5	47.4	48.9	50.4	43.9	40.6	41.6	43.8	45.7	44.2	45.0	46.2	50.8	48.8	50.1	51.1

Time Delay (ns) for Selected Areas-of-Interest
MRF, Hopfield, Goad and Exponential Model for 15 August 1995
(0000, 0600, 1200 and 1800 Hours)

AOI	MRF 0000	MRF 0600	MRF 1200	MRF 1800	Hopfield 0000	Hopfield 0600	Hopfield 1200	Hopfield 1800	Goad 0000	Goad 0600	Goad 1200	Goad 1800	Exponential 0000	Exponential 0600	Exponential 1200	Exponential 1800
Elevation Angle = 0°																
(1) Ahaggar, Algeria (AHAGR)	334.0	334.0	334.0	334.0	271.6	278.2	262.7	255.9	282.5	287.2	278.2	271.2	327.5	335.7	318.7	307.8
(2) Amazon Forest (AMFOR)	423.4	423.9	423.9	416.7	326.1	326.3	326.5	323.6	335.2	334.3	334.8	333.8	418.2	418.4	417.5	411.5
(3) Bangkok, Thailand (BANGK)	449.3	446.3	443.7	454.7	335.5	334.1	332.8	337.9	344.9	343.9	342.5	347.3	442.7	439.3	436.6	444.7
(4) Washington, D.C. (DC)	444.4	444.9	439.7	432.4	333.7	335.1	334.1	329.2	344.2	343.9	342.1	339.3	433.8	433.1	428.5	422.7
(5) Alaska (NAK)	364.7	366.3	364.7	365.7	302.8	303.6	303.1	304.1	303.7	304.6	304.1	305.0	366.6	368.0	366.5	367.8
(6) Northern Australia, Tanami Desert (NAUS)	336.7	322.7	332.2	338.3	287.8	272.4	283.2	289.2	291.7	281.6	288.4	292.4	340.6	325.7	335.7	341.5
(7) Pyrenee Mountains (PYRNES)	376.8	373.3	371.2	374.7	306.5	306.0	304.7	305.6	312.4	312.5	311.3	312.0	377.2	374.1	372.2	375.5
(8) Spokane, Washington (SPOK)	359.8	368.6	367.8	373.1	294.7	301.9	302.6	304.4	300.8	306.1	305.9	309.4	360.4	368.6	368.5	373.7
(9) Tehran, Iran (TEHRAN)	363.2	338.5	295.9	317.7	291.9	274.1	242.8	260.4	303.0	288.9	260.0	274.3	361.6	336.8	288.8	313.8
(10) Xining, China (XINING)	450.5	462.4	440.9	418.1	337.3	340.9	331.8	322.7	345.5	351.6	342.5	332.1	447.3	455.2	432.7	415.1
Elevation Angle = 1°																
(1) Ahaggar, Algeria (AHAGR)	229.8	233.3	226.0	220.8	189.3	193.5	183.0	179.3	199.6	202.1	197.6	193.6	231.2	235.8	226.5	219.9
(2) Amazon Forest (AMFOR)	278.7	278.6	278.3	276.0	219.6	220.0	220.1	217.9	228.6	227.9	228.3	227.9	279.0	279.0	278.0	275.0
(3) Bangkok, Thailand (BANGK)	296.4	294.4	293.1	297.2	224.6	223.8	223.0	226.0	233.9	233.4	232.6	235.2	294.3	291.9	290.9	293.6
(4) Washington, D.C. (DC)	287.9	288.2	286.1	282.1	223.4	224.7	224.4	221.1	233.8	233.5	232.4	231.1	284.0	282.8	280.1	277.3
(5) Alaska (NAK)	249.5	250.6	249.4	250.0	209.6	209.9	209.7	210.3	210.7	211.2	210.9	211.4	253.2	253.8	252.8	253.5
(6) Northern Australia, Tanami Desert (NAUS)	233.9	227.8	232.1	234.7	200.8	190.5	197.8	201.8	204.6	199.2	202.9	204.8	238.1	229.7	235.4	238.3
(7) Pyrenee Mountains (PYRNES)	256.0	254.5	253.6	254.9	210.0	209.6	208.8	209.3	215.9	215.9	215.3	215.7	258.5	256.8	255.9	257.6
(8) Spokane, Washington (SPOK)	248.5	252.4	251.7	254.4	203.1	207.5	208.2	208.6	209.1	211.8	211.6	213.6	249.5	253.0	253.1	255.6
(9) Tehran, Iran (TEHRAN)	250.9	237.7	215.6	227.4	200.2	189.2	171.0	181.9	210.8	203.2	187.1	195.0	249.1	235.8	208.1	223.1
(10) Xining, China (XINING)	297.7	304.2	292.6	279.1	226.0	227.2	222.2	217.8	234.1	237.8	232.8	227.0	297.6	299.2	285.2	277.6
Elevation Angle = 3°																
(1) Ahaggar, Algeria (AHAGR)	132.0	133.2	130.9	128.8	110.5	112.8	106.8	105.0	118.4	119.4	117.8	115.8	133.2	135.1	131.5	128.4
(2) Amazon Forest (AMFOR)	150.7	150.6	150.4	149.8	125.0	125.3	125.4	124.0	131.9	131.5	131.8	131.7	150.5	150.4	149.6	148.6
(3) Bangkok, Thailand (BANGK)	159.8	158.8	158.5	159.5	127.3	126.8	126.5	127.9	134.5	134.3	133.9	135.1	157.9	156.6	156.5	156.4
(4) Washington, D.C. (DC)	153.8	154.0	153.2	151.4	126.6	127.5	127.5	125.6	134.6	134.3	133.8	133.3	150.2	149.1	147.9	147.0
(5) Alaska (NAK)	139.5	140.0	139.3	139.6	121.7	121.9	121.8	122.1	122.8	123.0	122.9	123.2	142.2	142.3	141.9	142.1
(6) Northern Australia, Tanami Desert (NAUS)	132.6	130.7	132.2	133.0	117.4	111.5	115.7	117.9	120.3	118.1	119.6	120.3	135.6	132.3	134.6	135.4
(7) Pyrenee Mountains (PYRNES)	142.2	141.7	141.4	141.7	121.1	120.8	120.4	120.7	125.7	125.8	125.5	125.7	143.9	143.2	143.0	143.6
(8) Spokane, Washington (SPOK)	139.6	140.5	140.0	140.8	117.7	120.0	120.4	120.3	122.3	123.4	123.2	124.3	140.4	140.9	141.0	141.6
(9) Tehran, Iran (TEHRAN)	141.0	135.7	127.5	132.4	115.5	109.7	100.5	106.4	123.6	120.2	112.7	116.3	139.4	134.3	122.6	129.5
(10) Xining, China (XINING)	160.3	162.8	158.0	151.8	128.1	128.3	126.0	124.2	134.5	136.4	134.1	131.3	160.0	158.6	151.8	150.2
Elevation Angle = 5°																
(1) Ahaggar, Algeria (AHAGR)	89.3	89.9	88.7	87.4	75.5	77.0	73.0	71.8	81.4	82.0	81.2	79.9	90.2	91.2	89.3	87.4
(2) Amazon Forest (AMFOR)	100.2	100.0	99.9	99.7	84.7	85.0	85.0	84.1	90.0	89.7	89.9	89.9	99.5	99.4	98.9	98.3
(3) Bangkok, Thailand (BANGK)	106.0	105.3	105.1	105.7	86.1	85.8	85.6	86.6	91.6	91.5	91.2	92.0	104.2	103.3	103.4	103.0
(4) Washington, D.C. (DC)	101.9	102.0	101.5	100.4	85.7	86.3	86.3	85.1	91.7	91.5	91.1	90.9	98.7	97.9	97.1	96.6
(5) Alaska (NAK)	93.5	93.9	93.4	93.5	83.0	83.1	83.1	83.2	83.9	84.0	84.0	84.1	95.4	95.5	95.2	95.3
(6) Northern Australia, Tanami Desert (NAUS)	89.4	88.3	89.2	89.6	80.2	76.2	79.0	80.5	82.4	81.2	82.0	82.4	91.5	89.6	90.9	91.3
(7) Pyrenee Mountains (PYRNES)	95.2	94.9	94.8	94.9	82.4	82.2	81.9	82.1	85.9	86.0	85.8	85.9	96.2	95.9	95.7	96.1
(8) Spokane, Washington (SPOK)	93.6	94.0	93.7	94.1	80.2	81.7	82.0	81.8	83.7	84.3	84.1	84.9	94.2	94.2	94.3	94.5
(9) Tehran, Iran (TEHRAN)	94.6	91.6	86.9	89.8	78.6	74.8	68.8	72.7	84.7	82.7	78.0	80.2	93.4	90.6	83.7	88.0
(10) Xining, China (XINING)	106.3	107.7	104.8	101.0	86.7	86.7	85.3	84.2	91.6	92.9	91.4	89.6	105.7	104.3	99.9	99.5
Elevation Angle = 10°																
(1) Ahaggar, Algeria (AHAGR)	48.0	48.3	47.8	47.1	40.9	41.8	39.6	39.0	44.4	44.7	44.4	43.7	48.6	49.1	48.2	47.2
(2) Amazon Forest (AMFOR)	53.3	53.2	53.2	53.0	45.6	45.8	45.8	45.3	48.8	48.6	48.7	48.8	52.7	52.7	52.4	52.1
(3) Bangkok, Thailand (BANGK)	56.3	56.0	55.9	56.1	46.4	46.2	46.1	46.6	49.7	49.6	49.5	49.9	55.2	54.7	54.7	54.4
(4) Washington, D.C. (DC)	54.1	54.2	53.9	53.4	46.1	46.5	46.5	45.8	49.8	49.6	49.4	49.3	52.1	51.6	51.2	51.0
(5) Alaska (NAK)	50.0	50.2	50.0	50.0	44.9	45.0	45.0	45.1	45.5	45.6	45.6	45.6	51.1	51.1	50.9	51.0
(6) Northern Australia, Tanami Desert (NAUS)	48.0	47.5	47.9	48.1	43.5	41.4	42.9	43.7	44.8	44.3	44.6	44.8	49.1	48.2	48.9	49.0
(7) Pyrenee Mountains (PYRNES)	50.9	50.7	50.7	50.7	44.5	44.4	44.3	44.4	46.6	46.7	46.6	46.7	51.4	51.2	51.2	51.3
(8) Spokane, Washington (SPOK)	50.1	50.2	50.0	50.2	43.4	44.2	44.4	44.2	45.5	45.8	45.7	46.1	50.4	50.3	50.4	50.4
(9) Tehran, Iran (TEHRAN)	50.7	49.2	47.0	48.4	42.5	40.5	37.4	39.4	46.1	45.1	42.8	43.8	49.9	48.6	45.3	47.5
(10) Xining, China (XINING)	56.4	57.1	55.6	53.7	46.7	46.7	45.9	45.4	49.6	50.3	49.6	48.6	55.9	55.0	52.8	52.8

Time Delay (ns) for Selected Areas-of-Interest
MRF, Hopfield, Goad and Exponential Model for 15 November 1995
(0000, 0600, 1200 and 1800 Hours)

AOI	Elevation Angle = 0°															
	MRF				Hopfield				Goad				Exponential			
	0000	0600	1200	1800	0000	0600	1200	1800	0000	0600	1200	1800	0000	0600	1200	1800
(1) Ahaggar, Algeria (AHAGR)	334.0	334.0	334.0	334.0	283.0	285.8	269.1	271.1	288.4	289.9	279.0	280.2	337.2	339.3	322.2	323.2
(2) Amazon Forest (AMFOR)	429.2	425.7	427.7	419.4	328.2	326.8	327.7	323.2	337.4	335.3	336.5	333.5	423.4	420.3	422.0	414.4
(3) Bangkok, Thailand (BANGK)	429.9	429.1	427.9	425.7	326.9	326.6	325.8	325.1	336.0	335.6	335.1	334.3	426.6	424.9	423.5	421.2
(4) Washington, D.C. (DC)	344.8	338.9	337.3	335.4	295.4	293.5	293.3	291.3	293.9	291.2	290.5	290.0	348.1	342.0	340.6	340.0
(5) Alaska (NAK)	336.9	337.3	337.5	338.1	292.7	293.1	294.1	294.2	291.0	291.2	291.4	291.8	342.4	342.5	342.6	342.6
(6) Northern Australia, Tanami Desert (NAUS)	386.0	375.0	388.3	396.6	304.3	296.9	305.7	311.2	312.8	308.2	315.6	319.6	382.4	371.5	385.3	393.1
(7) Pyrenee Mountains (PYRNES)	349.2	348.1	348.5	349.2	295.5	294.7	294.7	295.4	295.9	295.6	295.7	296.1	353.6	352.4	352.8	353.5
(8) Spokane, Washington (SPOK)	374.3	371.0	364.2	365.5	307.5	306.9	304.1	304.4	310.1	308.7	305.7	306.0	375.5	372.2	368.1	370.0
(9) Tehran, Iran (TEHRAN)	320.8	318.3	313.8	320.5	275.7	272.1	266.3	276.3	280.7	279.2	275.9	281.5	322.0	319.4	314.7	323.5
(10) Xining, China (XINING)	345.0	327.5	332.1	339.2	293.3	277.4	281.7	287.9	295.8	284.6	287.5	292.0	350.2	331.7	336.6	343.9

	Elevation Angle = 1°															
	MRF				Hopfield				Goad				Exponential			
	0000	0600	1200	1800	0000	0600	1200	1800	0000	0600	1200	1800	0000	0600	1200	1800
(1) Ahaggar, Algeria (AHAGR)	232.9	234.0	225.9	226.0	197.5	199.6	188.4	189.9	202.7	203.5	197.8	198.4	236.8	237.8	228.4	228.9
(2) Amazon Forest (AMFOR)	285.5	283.6	284.9	281.7	220.7	220.1	220.6	217.7	229.8	228.6	229.4	227.7	281.0	279.5	280.4	276.6
(3) Bangkok, Thailand (BANGK)	288.9	287.1	287.3	286.2	219.9	219.8	219.3	218.9	228.9	228.7	228.4	228.0	285.9	284.5	283.6	282.0
(4) Washington, D.C. (DC)	238.5	234.8	233.7	232.6	205.8	205.0	205.3	203.9	204.6	203.1	202.8	202.8	241.9	237.9	237.0	237.2
(5) Alaska (NAK)	233.1	233.7	233.4	233.8	204.9	205.2	206.1	206.1	203.4	203.6	203.7	204.1	238.6	238.7	238.8	238.6
(6) Northern Australia, Tanami Desert (NAUS)	265.3	260.2	265.8	268.8	207.9	202.8	208.1	211.6	216.2	213.7	217.8	219.8	261.1	255.3	263.0	266.6
(7) Pyrenee Mountains (PYRNES)	240.7	240.3	240.4	240.7	205.8	205.1	205.1	205.5	206.3	206.1	206.2	206.4	245.6	244.9	245.1	245.4
(8) Spokane, Washington (SPOK)	255.2	253.0	248.8	249.5	211.6	211.5	209.9	210.1	214.3	213.5	211.8	211.9	257.4	254.9	253.3	254.8
(9) Tehran, Iran (TEHRAN)	227.0	225.9	223.3	226.0	194.0	191.4	187.2	194.3	198.8	198.0	196.2	199.2	228.0	226.6	223.7	228.9
(10) Xining, China (XINING)	239.4	229.5	232.0	235.8	204.4	193.9	196.7	200.7	206.9	200.6	202.2	204.7	244.9	234.1	236.9	240.8

	Elevation Angle = 3°															
	MRF				Hopfield				Goad				Exponential			
	0000	0600	1200	1800	0000	0600	1200	1800	0000	0600	1200	1800	0000	0600	1200	1800
(1) Ahaggar, Algeria (AHAGR)	132.6	133.0	130.1	130.0	115.5	116.7	110.4	111.2	119.4	119.7	117.5	117.7	135.6	135.9	132.3	132.4
(2) Amazon Forest (AMFOR)	154.6	153.8	154.6	153.5	125.5	125.3	125.6	123.9	132.6	131.9	132.3	131.6	150.6	150.2	150.6	149.2
(3) Bangkok, Thailand (BANGK)	157.4	156.2	156.6	156.1	125.1	125.0	124.8	124.6	132.1	132.0	131.8	131.6	154.8	154.0	153.4	152.6
(4) Washington, D.C. (DC)	133.9	132.1	131.6	131.2	120.1	119.9	120.2	119.4	119.4	118.6	118.5	118.7	136.7	134.6	134.3	134.8
(5) Alaska (NAK)	131.2	131.6	131.4	131.7	120.0	120.2	120.8	120.8	119.0	119.1	119.2	119.4	135.6	135.6	135.7	135.5
(6) Northern Australia, Tanami Desert (NAUS)	147.8	146.0	147.8	148.4	119.6	116.7	119.5	121.3	126.0	125.0	126.9	127.7	144.5	142.3	145.5	146.4
(7) Pyrenee Mountains (PYRNES)	135.1	135.0	135.0	135.0	120.1	119.6	119.6	119.9	120.6	120.6	120.6	120.7	138.9	138.6	138.7	138.7
(8) Spokane, Washington (SPOK)	141.7	140.5	138.4	138.7	122.4	122.4	121.7	121.8	124.7	124.2	123.3	123.4	143.3	141.7	141.6	142.6
(9) Tehran, Iran (TEHRAN)	130.8	130.4	129.3	129.9	114.1	112.4	110.0	114.1	117.7	117.5	116.8	117.9	131.9	131.3	130.0	132.4
(10) Xining, China (XINING)	135.2	131.1	132.1	133.6	119.3	113.4	115.0	117.2	121.4	118.5	119.2	120.3	139.6	134.9	136.0	137.5

	Elevation Angle = 5°															
	MRF				Hopfield				Goad				Exponential			
	0000	0600	1200	1800	0000	0600	1200	1800	0000	0600	1200	1800	0000	0600	1200	1800
(1) Ahaggar, Algeria (AHAGR)	89.4	89.7	88.0	88.0	78.9	79.7	75.5	76.0	81.9	82.1	80.8	80.9	91.6	91.8	89.7	89.8
(2) Amazon Forest (AMFOR)	102.6	102.2	102.7	102.1	85.0	85.0	85.1	84.0	90.4	89.9	90.2	89.8	99.4	99.2	99.5	98.6
(3) Bangkok, Thailand (BANGK)	104.6	103.8	104.0	103.8	84.8	84.7	84.5	84.5	90.1	90.0	89.9	89.8	102.5	101.9	101.5	101.0
(4) Washington, D.C. (DC)	89.8	88.6	88.4	88.1	82.0	81.9	82.1	81.6	81.5	81.0	80.9	81.2	91.9	90.5	90.4	90.9
(5) Alaska (NAK)	88.0	88.4	88.2	88.4	82.0	82.2	82.6	82.6	81.3	81.4	81.4	81.6	91.3	91.4	91.4	91.2
(6) Northern Australia, Tanami Desert (NAUS)	98.9	97.9	98.8	99.0	81.4	79.4	81.2	82.4	86.2	85.6	86.8	87.2	96.5	95.2	97.1	97.4
(7) Pyrenee Mountains (PYRNES)	90.7	90.6	90.6	90.6	82.0	81.7	81.7	81.8	82.5	82.4	82.5	82.5	93.4	93.3	93.3	93.3
(8) Spokane, Washington (SPOK)	94.8	94.0	92.7	92.8	83.3	83.4	83.0	83.0	85.1	84.8	84.2	84.2	95.8	94.8	94.9	95.5
(9) Tehran, Iran (TEHRAN)	88.4	88.3	87.6	87.9	78.1	76.9	75.2	78.1	80.8	80.7	80.4	81.0	89.5	89.1	88.3	89.8
(10) Xining, China (XINING)	90.9	88.5	89.0	89.9	81.5	77.5	78.6	80.0	83.1	81.4	81.8	82.4	94.1	91.4	92.0	92.8

	Elevation Angle = 10°															
	MRF				Hopfield				Goad				Exponential			
	0000	0600	1200	1800	0000	0600	1200	1800	0000	0600	1200	1800	0000	0600	1200	1800
(1) Ahaggar, Algeria (AHAGR)	48.0	48.1	47.3	47.3	42.8	43.3	41.0	41.3	44.6	44.6	44.1	44.1	49.2	49.3	48.4	48.4
(2) Amazon Forest (AMFOR)	54.5	54.3	54.6	54.3	45.8	45.8	45.9	45.3	49.0	48.8	48.9	48.7	52.6	52.5	52.7	52.3
(3) Bangkok, Thailand (BANGK)	55.6	55.2	55.3	55.2	45.7	45.7	45.6	45.5	48.9	48.8	48.8	48.7	54.3	54.0	53.8	53.5
(4) Washington, D.C. (DC)	48.0	47.4	47.3	47.2	44.5	44.4	44.6	44.3	44.2	44.0	43.9	44.1	49.2	48.5	48.5	48.8
(5) Alaska (NAK)	47.1	47.3	47.2	47.3	44.5	44.6	44.8	44.8	44.1	44.2	44.2	44.3	49.0	49.0	49.1	49.0
(6) Northern Australia, Tanami Desert (NAUS)	52.8	52.3	52.8	52.8	44.0	42.9	43.8	44.5	46.8	46.6	47.2	47.4	51.4	50.8	51.7	51.8
(7) Pyrenee Mountains (PYRNES)	48.5	48.5	48.4	48.4	44.4	44.3	44.3	44.4	44.8	44.8	44.8	44.8	50.1	50.0	50.0	50.0
(8) Spokane, Washington (SPOK)	50.6	50.2	49.5	49.6	45.1	45.1	44.9	44.9	46.2	46.0	45.7	45.7	51.2	50.6	50.7	51.1
(9) Tehran, Iran (TEHRAN)	47.6	47.5	47.1	47.2	42.4	41.8	40.9	42.4	44.0	44.0	43.9	44.1	48.2	48.1	47.7	48.4
(10) Xining, China (XINING)	48.7	47.5	47.8	48.2	44.2	42.0	42.6	43.4	45.1	44.3	44.5	44.8	50.6	49.2	49.5	49.8

Angle Error (degrees) for Selected Areas-of-Interest
MRF, Goad and Exponential Model for 15 February 1995
(0000, 0600, 1200 and 1800 Hours)

AOI	Elevation Angle = 0°											
	MRF				Goad				Exponential			
	0000	0600	1200	1800	0000	0600	1200	1800	0000	0600	1200	1800
(1) Ahaggar, Algeria (AHAGR)	0.2701	0.2912	0.2346	0.2362	0.5756	0.5906	0.5311	0.5330	0.2635	0.2709	0.2397	0.2381
(2) Amazon Forest (AMFOR)	0.4807	0.4786	0.4852	0.4867	0.9099	0.9040	0.9029	0.9144	0.4489	0.4453	0.4473	0.4500
(3) Bangkok, Thailand (BANGK)	0.5054	0.4467	0.4617	0.4684	0.9090	0.8637	0.8850	0.8946	0.4623	0.4301	0.4458	0.4537
(4) Washington, D.C. (DC)	0.2672	0.2660	0.2734	0.2960	0.5833	0.5886	0.6193	0.6689	0.2724	0.2737	0.2876	0.3100
(5) Alaska (NAK)	0.3048	0.3061	0.3072	0.3113	0.6169	0.6201	0.6160	0.6187	0.2833	0.2847	0.2824	0.2843
(6) Northern Australia, Tanami Desert (NAUS)	0.4198	0.3078	0.3496	0.3978	0.8229	0.7295	0.7693	0.8060	0.3834	0.3106	0.3343	0.3655
(7) Pyrenee Mountains (PYRNES)	0.3096	0.3089	0.3107	0.3163	0.6189	0.6214	0.6193	0.6260	0.2914	0.2912	0.2912	0.2936
(8) Spokane, Washington (SPOK)	0.2731	0.2875	0.2768	0.2788	0.5845	0.6030	0.5945	0.6130	0.2762	0.2861	0.2755	0.2749
(9) Tehran, Iran (TEHRAN)	0.3372	0.3385	0.3309	0.3324	0.6933	0.6969	0.7020	0.6989	0.3157	0.3198	0.3239	0.3230
(10) Xining, China (XINING)	0.3003	0.2857	0.2842	0.3007	0.6310	0.6065	0.6053	0.6339	0.2956	0.2739	0.2734	0.2901
	Elevation Angle = 1°											
	MRF				Goad				Exponential			
	0000	0600	1200	1800	0000	0600	1200	1800	0000	0600	1200	1800
(1) Ahaggar, Algeria (AHAGR)	0.2376	0.2528	0.2141	0.2122	0.4225	0.4319	0.3939	0.3952	0.2326	0.2386	0.2128	0.2114
(2) Amazon Forest (AMFOR)	0.3939	0.3918	0.3944	0.3965	0.6179	0.6144	0.6138	0.6205	0.3813	0.3784	0.3795	0.3822
(3) Bangkok, Thailand (BANGK)	0.4055	0.3723	0.3853	0.3878	0.6173	0.5904	0.6029	0.6087	0.3914	0.3666	0.3795	0.3845
(4) Washington, D.C. (DC)	0.2402	0.2398	0.2464	0.2648	0.4301	0.4336	0.4511	0.4783	0.2396	0.2408	0.2522	0.2705
(5) Alaska (NAK)	0.2623	0.2638	0.2635	0.2662	0.4483	0.4501	0.4478	0.4494	0.2494	0.2506	0.2487	0.2502
(6) Northern Australia, Tanami Desert (NAUS)	0.3476	0.2773	0.2990	0.3312	0.5658	0.5095	0.5336	0.5556	0.3328	0.2791	0.2952	0.3206
(7) Pyrenee Mountains (PYRNES)	0.2665	0.2662	0.2670	0.2704	0.4498	0.4511	0.4498	0.4537	0.2549	0.2547	0.2547	0.2568
(8) Spokane, Washington (SPOK)	0.2430	0.2532	0.2460	0.2514	0.4317	0.4432	0.4368	0.4458	0.2423	0.2501	0.2432	0.2478
(9) Tehran, Iran (TEHRAN)	0.2875	0.2895	0.2875	0.2885	0.4912	0.4934	0.4959	0.4946	0.2754	0.2786	0.2823	0.2812
(10) Xining, China (XINING)	0.2631	0.2486	0.2476	0.2614	0.4575	0.4402	0.4399	0.4578	0.2589	0.2412	0.2406	0.2543
	Elevation Angle = 3°											
	MRF				Goad				Exponential			
	0000	0600	1200	1800	0000	0600	1200	1800	0000	0600	1200	1800
(1) Ahaggar, Algeria (AHAGR)	0.1506	0.1573	0.1393	0.1378	0.2530	0.2577	0.2380	0.2387	0.1481	0.1516	0.1368	0.1361
(2) Amazon Forest (AMFOR)	0.2322	0.2310	0.2316	0.2329	0.3475	0.3458	0.3456	0.3488	0.2327	0.2311	0.2315	0.2332
(3) Bangkok, Thailand (BANGK)	0.2355	0.2220	0.2286	0.2298	0.3471	0.3339	0.3400	0.3429	0.2376	0.2245	0.2316	0.2339
(4) Washington, D.C. (DC)	0.1537	0.1540	0.1588	0.1691	0.2579	0.2597	0.2680	0.2805	0.1516	0.1524	0.1592	0.1700
(5) Alaska (NAK)	0.1639	0.1648	0.1642	0.1653	0.2659	0.2667	0.2656	0.2664	0.1586	0.1593	0.1582	0.1590
(6) Northern Australia, Tanami Desert (NAUS)	0.2085	0.1766	0.1862	0.2013	0.3217	0.2936	0.3057	0.3166	0.2072	0.1781	0.1869	0.2011
(7) Pyrenee Mountains (PYRNES)	0.1660	0.1659	0.1661	0.1676	0.2668	0.2674	0.2668	0.2687	0.1610	0.1609	0.1609	0.1621
(8) Spokane, Washington (SPOK)	0.1558	0.1608	0.1575	0.1608	0.2587	0.2645	0.2609	0.2645	0.1535	0.1579	0.1546	0.1581
(9) Tehran, Iran (TEHRAN)	0.1775	0.1789	0.1797	0.1796	0.2861	0.2872	0.2882	0.2878	0.1734	0.1751	0.1775	0.1765
(10) Xining, China (XINING)	0.1649	0.1573	0.1567	0.1640	0.2710	0.2613	0.2613	0.2705	0.1624	0.1536	0.1530	0.1605
	Elevation Angle = 5°											
	MRF				Goad				Exponential			
	0000	0600	1200	1800	0000	0600	1200	1800	0000	0600	1200	1800
(1) Ahaggar, Algeria (AHAGR)	0.1042	0.1082	0.0969	0.0961	0.1747	0.1778	0.1650	0.1655	0.1026	0.1050	0.0951	0.0946
(2) Amazon Forest (AMFOR)	0.1566	0.1558	0.1561	0.1569	0.2349	0.2338	0.2337	0.2358	0.1584	0.1573	0.1576	0.1587
(3) Bangkok, Thailand (BANGK)	0.1582	0.1501	0.1542	0.1551	0.2347	0.2262	0.2301	0.2320	0.1613	0.1529	0.1575	0.1590
(4) Washington, D.C. (DC)	0.1065	0.1068	0.1103	0.1170	0.1780	0.1792	0.1844	0.1923	0.1048	0.1054	0.1099	0.1172
(5) Alaska (NAK)	0.1128	0.1134	0.1129	0.1136	0.1828	0.1834	0.1827	0.1832	0.1096	0.1100	0.1093	0.1098
(6) Northern Australia, Tanami Desert (NAUS)	0.1413	0.1217	0.1277	0.1371	0.2184	0.2004	0.2081	0.2151	0.1419	0.1228	0.1287	0.1379
(7) Pyrenee Mountains (PYRNES)	0.1142	0.1141	0.1142	0.1151	0.1835	0.1839	0.1835	0.1847	0.1111	0.1110	0.1110	0.1118
(8) Spokane, Washington (SPOK)	0.1079	0.1112	0.1090	0.1111	0.1784	0.1821	0.1797	0.1819	0.1060	0.1089	0.1067	0.1091
(9) Tehran, Iran (TEHRAN)	0.1217	0.1227	0.1235	0.1233	0.1958	0.1965	0.1971	0.1969	0.1195	0.1206	0.1221	0.1215
(10) Xining, China (XINING)	0.1136	0.1087	0.1083	0.1131	0.1864	0.1799	0.1800	0.1859	0.1120	0.1063	0.1058	0.1108
	Elevation Angle = 10°											
	MRF				Goad				Exponential			
	0000	0600	1200	1800	0000	0600	1200	1800	0000	0600	1200	1800
(1) Ahaggar, Algeria (AHAGR)	0.0564	0.0583	0.0527	0.0522	0.0948	0.0964	0.0899	0.0901	0.0555	0.0568	0.0516	0.0514
(2) Amazon Forest (AMFOR)	0.0832	0.0828	0.0830	0.0834	0.1257	0.1251	0.1250	0.1261	0.0846	0.0841	0.0842	0.0848
(3) Bangkok, Thailand (BANGK)	0.0839	0.0799	0.0820	0.0825	0.1255	0.1212	0.1232	0.1242	0.0861	0.0818	0.0842	0.0849
(4) Washington, D.C. (DC)	0.0577	0.0579	0.0598	0.0632	0.0965	0.0971	0.0998	0.1038	0.0567	0.0570	0.0594	0.0632
(5) Alaska (NAK)	0.0608	0.0611	0.0609	0.0612	0.0989	0.0992	0.0988	0.0991	0.0592	0.0594	0.0590	0.0593
(6) Northern Australia, Tanami Desert (NAUS)	0.0754	0.0656	0.0687	0.0734	0.1172	0.1079	0.1119	0.1155	0.0761	0.0662	0.0693	0.0741
(7) Pyrenee Mountains (PYRNES)	0.0615	0.0615	0.0616	0.0620	0.0993	0.0995	0.0993	0.0999	0.0600	0.0599	0.0599	0.0604
(8) Spokane, Washington (SPOK)	0.0584	0.0601	0.0590	0.0601	0.0966	0.0985	0.0972	0.0983	0.0572	0.0588	0.0576	0.0589
(9) Tehran, Iran (TEHRAN)	0.0655	0.0660	0.0664	0.0663	0.1056	0.1059	0.1062	0.1061	0.0644	0.0650	0.0658	0.0654
(10) Xining, China (XINING)	0.0613	0.0588	0.0586	0.0611	0.1008	0.0974	0.0975	0.1005	0.0604	0.0575	0.0572	0.0598

Angle Error (degrees) **for Selected Areas-of-Interest**
MRF, Goad and Exponential Model for 15 May 1995
(0000, 0600, 1200 and 1800 Hours)

AOI	Elevation Angle = 0°											
	MRF				Goad				Exponential			
	0000	0600	1200	1800	0000	0600	1200	1800	0000	0600	1200	1800
(1) Ahaggar, Algeria (AHAGR)	0.2334	0.2478	0.2001	0.1940	0.5020	0.5179	0.4746	0.4651	0.2204	0.2294	0.2044	0.2000
(2) Amazon Forest (AMFOR)	0.5059	0.4913	0.4976	0.5010	0.9436	0.9312	0.9261	0.9364	0.4753	0.4595	0.4545	0.4601
(3) Bangkok, Thailand (BANGK)	0.4953	0.5355	0.4995	0.5437	0.9389	0.9578	0.9270	0.9780	0.4540	0.4704	0.4495	0.4955
(4) Washington, D.C. (DC)	0.4817	0.4650	0.4458	0.4073	0.8483	0.8218	0.7983	0.7666	0.4175	0.4005	0.3823	0.3647
(5) Alaska (NAK)	0.3124	0.3137	0.3128	0.3116	0.6388	0.6410	0.6379	0.6397	0.2946	0.2960	0.2957	0.2962
(6) Northern Australia, Tanami Desert (NAUS)	0.3042	0.2765	0.3046	0.3363	0.6818	0.6781	0.7115	0.7359	0.3207	0.3051	0.3289	0.3461
(7) Pyrenee Mountains (PYRNES)	0.3358	0.3246	0.3187	0.3299	0.6776	0.6776	0.6687	0.6724	0.3082	0.3008	0.2962	0.3043
(8) Spokane, Washington (SPOK)	0.3315	0.3815	0.3336	0.3634	0.7008	0.7822	0.7111	0.7458	0.3160	0.3597	0.3208	0.3441
(9) Tehran, Iran (TEHRAN)	0.3500	0.3226	0.2980	0.3370	0.7377	0.7054	0.6828	0.7317	0.3400	0.3233	0.3058	0.3413
(10) Xining, China (XINING)	0.3243	0.2506	0.2797	0.3457	0.6746	0.5606	0.6238	0.7201	0.3080	0.2367	0.2636	0.3258
	Elevation Angle = 1°											
	MRF				Goad				Exponential			
	0000	0600	1200	1800	0000	0600	1200	1800	0000	0600	1200	1800
(1) Ahaggar, Algeria (AHAGR)	0.2024	0.2129	0.1804	0.1756	0.3763	0.3867	0.3573	0.3517	0.1968	0.2043	0.1836	0.1801
(2) Amazon Forest (AMFOR)	0.4108	0.4010	0.4024	0.4069	0.6379	0.6305	0.6276	0.6336	0.4015	0.3899	0.3858	0.3912
(3) Bangkok, Thailand (BANGK)	0.4067	0.4277	0.4077	0.4359	0.6350	0.6462	0.6278	0.6583	0.3877	0.4002	0.3851	0.4179
(4) Washington, D.C. (DC)	0.3853	0.3719	0.3560	0.3365	0.5813	0.5658	0.5520	0.5331	0.3573	0.3438	0.3293	0.3153
(5) Alaska (NAK)	0.2695	0.2704	0.2695	0.2691	0.4608	0.4621	0.4606	0.4616	0.2580	0.2590	0.2587	0.2591
(6) Northern Australia, Tanami Desert (NAUS)	0.2696	0.2527	0.2722	0.2934	0.4831	0.4801	0.5008	0.5155	0.2796	0.2674	0.2860	0.2998
(7) Pyrenee Mountains (PYRNES)	0.2851	0.2776	0.2730	0.2813	0.4818	0.4816	0.4764	0.4786	0.2697	0.2637	0.2599	0.2666
(8) Spokane, Washington (SPOK)	0.2901	0.3281	0.2927	0.3147	0.4939	0.5422	0.5005	0.5208	0.2781	0.3146	0.2832	0.3016
(9) Tehran, Iran (TEHRAN)	0.3015	0.2836	0.2648	0.2950	0.5163	0.4964	0.4823	0.5121	0.2958	0.2826	0.2697	0.2968
(10) Xining, China (XINING)	0.2808	0.2230	0.2492	0.2987	0.4795	0.4091	0.4470	0.5052	0.2692	0.2152	0.2398	0.2862
	Elevation Angle = 3°											
	MRF				Goad				Exponential			
	0000	0600	1200	1800	0000	0600	1200	1800	0000	0600	1200	1800
(1) Ahaggar, Algeria (AHAGR)	0.1302	0.1355	0.1201	0.1174	0.2292	0.2346	0.2188	0.2160	0.1280	0.1324	0.1203	0.1184
(2) Amazon Forest (AMFOR)	0.2411	0.2366	0.2362	0.2389	0.3573	0.3537	0.3523	0.3551	0.2435	0.2376	0.2354	0.2387
(3) Bangkok, Thailand (BANGK)	0.2395	0.2470	0.2387	0.2521	0.3558	0.3613	0.3522	0.3673	0.2374	0.2439	0.2361	0.2526
(4) Washington, D.C. (DC)	0.2239	0.2167	0.2089	0.2009	0.3296	0.3220	0.3154	0.3060	0.2197	0.2121	0.2042	0.1964
(5) Alaska (NAK)	0.1683	0.1687	0.1682	0.1682	0.2719	0.2726	0.2720	0.2724	0.1632	0.1637	0.1635	0.1637
(6) Northern Australia, Tanami Desert (NAUS)	0.1724	0.1652	0.1747	0.1845	0.2816	0.2798	0.2903	0.2977	0.1761	0.1696	0.1796	0.1874
(7) Pyrenee Mountains (PYRNES)	0.1758	0.1722	0.1697	0.1739	0.2814	0.2813	0.2787	0.2798	0.1705	0.1672	0.1650	0.1688
(8) Spokane, Washington (SPOK)	0.1806	0.2006	0.1825	0.1933	0.2867	0.3103	0.2900	0.2999	0.1762	0.1971	0.1793	0.1895
(9) Tehran, Iran (TEHRAN)	0.1873	0.1789	0.1700	0.1851	0.2979	0.2878	0.2806	0.2956	0.1857	0.1784	0.1716	0.1863
(10) Xining, China (XINING)	0.1745	0.1436	0.1586	0.1847	0.2801	0.2443	0.2631	0.2922	0.1701	0.1402	0.1550	0.1809
	Elevation Angle = 5°											
	MRF				Goad				Exponential			
	0000	0600	1200	1800	0000	0600	1200	1800	0000	0600	1200	1800
(1) Ahaggar, Algeria (AHAGR)	0.0909	0.0942	0.0845	0.0828	0.1593	0.1628	0.1525	0.1507	0.0893	0.0922	0.0841	0.0827
(2) Amazon Forest (AMFOR)	0.1624	0.1597	0.1592	0.1610	0.2412	0.2389	0.2380	0.2398	0.1654	0.1617	0.1602	0.1624
(3) Bangkok, Thailand (BANGK)	0.1614	0.1657	0.1605	0.1690	0.2402	0.2437	0.2379	0.2476	0.1617	0.1658	0.1608	0.1713
(4) Washington, D.C. (DC)	0.1506	0.1460	0.1411	0.1362	0.2234	0.2186	0.2144	0.2084	0.1499	0.1449	0.1398	0.1347
(5) Alaska (NAK)	0.1158	0.1161	0.1158	0.1158	0.1867	0.1872	0.1868	0.1871	0.1127	0.1130	0.1128	0.1130
(6) Northern Australia, Tanami Desert (NAUS)	0.1192	0.1148	0.1209	0.1269	0.1929	0.1916	0.1984	0.2031	0.1213	0.1171	0.1236	0.1288
(7) Pyrenee Mountains (PYRNES)	0.1205	0.1182	0.1167	0.1193	0.1927	0.1926	0.1910	0.1917	0.1176	0.1154	0.1139	0.1165
(8) Spokane, Washington (SPOK)	0.1238	0.1367	0.1251	0.1319	0.1960	0.2111	0.1981	0.2044	0.1215	0.1352	0.1235	0.1301
(9) Tehran, Iran (TEHRAN)	0.1284	0.1231	0.1177	0.1272	0.2032	0.1968	0.1921	0.2017	0.1277	0.1229	0.1184	0.1281
(10) Xining, China (XINING)	0.1198	0.0997	0.1096	0.1263	0.1919	0.1688	0.1808	0.1995	0.1174	0.0975	0.1075	0.1246
	Elevation Angle = 10°											
	MRF				Goad				Exponential			
	0000	0600	1200	1800	0000	0600	1200	1800	0000	0600	1200	1800
(1) Ahaggar, Algeria (AHAGR)	0.0495	0.0512	0.0463	0.0454	0.0869	0.0887	0.0834	0.0825	0.0486	0.0501	0.0458	0.0451
(2) Amazon Forest (AMFOR)	0.0863	0.0849	0.0846	0.0855	0.1289	0.1277	0.1273	0.1282	0.0883	0.0864	0.0856	0.0867
(3) Bangkok, Thailand (BANGK)	0.0858	0.0878	0.0852	0.0896	0.1284	0.1302	0.1272	0.1322	0.0864	0.0885	0.0859	0.0913
(4) Washington, D.C. (DC)	0.0800	0.0776	0.0752	0.0727	0.1197	0.1173	0.1151	0.1120	0.0802	0.0777	0.0750	0.0723
(5) Alaska (NAK)	0.0625	0.0626	0.0624	0.0625	0.1009	0.1011	0.1009	0.1011	0.0608	0.0610	0.0609	0.0610
(6) Northern Australia, Tanami Desert (NAUS)	0.0644	0.0622	0.0654	0.0684	0.1041	0.1035	0.1070	0.1094	0.0654	0.0632	0.0666	0.0693
(7) Pyrenee Mountains (PYRNES)	0.0648	0.0636	0.0628	0.0642	0.1040	0.1039	0.1031	0.1035	0.0635	0.0623	0.0615	0.0629
(8) Spokane, Washington (SPOK)	0.0665	0.0732	0.0672	0.0706	0.1057	0.1134	0.1067	0.1100	0.0655	0.0727	0.0665	0.0700
(9) Tehran, Iran (TEHRAN)	0.0690	0.0663	0.0636	0.0684	0.1094	0.1061	0.1037	0.1086	0.0688	0.0662	0.0639	0.0689
(10) Xining, China (XINING)	0.0645	0.0541	0.0593	0.0678	0.1036	0.0917	0.0979	0.1074	0.0634	0.0529	0.0582	0.0672

Angle Error (degrees) for Selected Areas-of-Interest
MRF, Goad and Exponential Model for 15 August 1995
(0000, 0600, 1200 and 1800 Hours)

AOI	Elevation Angle = 0°											
	MRF				Goad				Exponential			
	0000	0600	1200	1800	0000	0600	1200	1800	0000	0600	1200	1800
(1) Ahaggar, Algeria (AHAGR)	0.2542	0.2851	0.2288	0.1994	0.5535	0.5818	0.5278	0.4878	0.2437	0.2597	0.2259	0.2095
(2) Amazon Forest (AMFOR)	0.4824	0.4875	0.4904	0.5383	0.8894	0.8853	0.8862	1.0088	0.4265	0.4275	0.4313	0.5159
(3) Bangkok, Thailand (BANGK)	0.4914	0.4900	0.4840	0.5214	0.9510	0.9438	0.9362	0.9648	0.4533	0.4519	0.4431	0.4711
(4) Washington, D.C. (DC)	0.5401	0.5402	0.5255	0.5140	0.9405	0.9411	0.9307	0.9090	0.4825	0.4885	0.4829	0.4701
(5) Alaska (NAK)	0.3457	0.3450	0.3462	0.3468	0.6860	0.6926	0.6876	0.6930	0.3182	0.3217	0.3202	0.3235
(6) Northern Australia, Tanami Desert (NAUS)	0.2886	0.2340	0.2701	0.2930	0.5957	0.5401	0.5779	0.6033	0.2751	0.2459	0.2647	0.2790
(7) Pyrenee Mountains (PYRNES)	0.3706	0.4329	0.3518	0.3662	0.7421	0.8780	0.7341	0.7391	0.3414	0.4293	0.3308	0.3376
(8) Spokane, Washington (SPOK)	0.3093	0.3368	0.3385	0.3492	0.6775	0.7154	0.7140	0.7386	0.3047	0.3269	0.3259	0.3367
(9) Tehran, Iran (TEHRAN)	0.3134	0.2581	0.1440	0.1985	0.6876	0.6018	0.4327	0.5122	0.3146	0.2636	0.1782	0.2199
(10) Xining, China (XINING)	0.4893	0.5081	0.4699	0.4417	0.9555	0.9913	0.9326	0.8648	0.4580	0.4905	0.4664	0.4226
	Elevation Angle = 1°											
	MRF				Goad				Exponential			
	0000	0600	1200	1800	0000	0600	1200	1800	0000	0600	1200	1800
(1) Ahaggar, Algeria (AHAGR)	0.2203	0.2401	0.2005	0.1809	0.4058	0.4233	0.3889	0.3647	0.2168	0.2300	0.2019	0.1884
(2) Amazon Forest (AMFOR)	0.3895	0.3913	0.3923	0.4418	0.6056	0.6032	0.6038	0.6770	0.3651	0.3657	0.3678	0.4325
(3) Bangkok, Thailand (BANGK)	0.4009	0.3995	0.3937	0.4157	0.6422	0.6379	0.6334	0.6505	0.3874	0.3863	0.3800	0.4001
(4) Washington, D.C. (DC)	0.4284	0.4280	0.4202	0.4132	0.6363	0.6366	0.6304	0.6176	0.4065	0.4102	0.4056	0.3961
(5) Alaska (NAK)	0.2912	0.2921	0.2921	0.2942	0.4874	0.4912	0.4883	0.4916	0.2776	0.2804	0.2790	0.2816
(6) Northern Australia, Tanami Desert (NAUS)	0.2530	0.2163	0.2401	0.2558	0.4342	0.3989	0.4231	0.4387	0.2420	0.2178	0.2334	0.2450
(7) Pyrenee Mountains (PYRNES)	0.3109	0.3674	0.2993	0.3081	0.5190	0.5991	0.5142	0.5172	0.2964	0.3661	0.2880	0.2934
(8) Spokane, Washington (SPOK)	0.2716	0.2938	0.2949	0.3071	0.4802	0.5028	0.5022	0.5162	0.2696	0.2890	0.2880	0.2994
(9) Tehran, Iran (TEHRAN)	0.2773	0.2330	0.1428	0.1844	0.4852	0.4329	0.3300	0.3795	0.2770	0.2368	0.1673	0.1992
(10) Xining, China (XINING)	0.4051	0.4219	0.3936	0.3707	0.6449	0.6663	0.6314	0.5913	0.3901	0.4163	0.3958	0.3606
	Elevation Angle = 3°											
	MRF				Goad				Exponential			
	0000	0600	1200	1800	0000	0600	1200	1800	0000	0600	1200	1800
(1) Ahaggar, Algeria (AHAGR)	0.1414	0.1506	0.1313	0.1216	0.2432	0.2521	0.2342	0.2222	0.1403	0.1480	0.1316	0.1235
(2) Amazon Forest (AMFOR)	0.2281	0.2285	0.2286	0.2585	0.3414	0.3402	0.3406	0.3766	0.2246	0.2248	0.2256	0.2603
(3) Bangkok, Thailand (BANGK)	0.2381	0.2371	0.2341	0.2436	0.3593	0.3572	0.3550	0.3635	0.2376	0.2369	0.2337	0.2439
(4) Washington, D.C. (DC)	0.2466	0.2464	0.2430	0.2392	0.3566	0.3568	0.3538	0.3474	0.2461	0.2475	0.2448	0.2399
(5) Alaska (NAK)	0.1790	0.1801	0.1795	0.1809	0.2844	0.2862	0.2849	0.2865	0.1751	0.1767	0.1757	0.1771
(6) Northern Australia, Tanami Desert (NAUS)	0.1580	0.1414	0.1521	0.1594	0.2586	0.2403	0.2529	0.2608	0.1537	0.1401	0.1490	0.1556
(7) Pyrenee Mountains (PYRNES)	0.1894	0.2223	0.1842	0.1880	0.2993	0.3383	0.2969	0.2984	0.1860	0.2247	0.1812	0.1843
(8) Spokane, Washington (SPOK)	0.1724	0.1838	0.1839	0.1908	0.2799	0.2911	0.2909	0.2974	0.1716	0.1827	0.1822	0.1889
(9) Tehran, Iran (TEHRAN)	0.1750	0.1513	0.1030	0.1254	0.2820	0.2558	0.2042	0.2295	0.1759	0.1530	0.1115	0.1305
(10) Xining, China (XINING)	0.2411	0.2507	0.2361	0.2223	0.3607	0.3712	0.3541	0.3345	0.2389	0.2529	0.2410	0.2216
	Elevation Angle = 5°											
	MRF				Goad				Exponential			
	0000	0600	1200	1800	0000	0600	1200	1800	0000	0600	1200	1800
(1) Ahaggar, Algeria (AHAGR)	0.0983	0.1041	0.0920	0.0857	0.1682	0.1739	0.1624	0.1547	0.0976	0.1027	0.0917	0.0863
(2) Amazon Forest (AMFOR)	0.1537	0.1539	0.1539	0.1737	0.2310	0.2303	0.2305	0.2536	0.1533	0.1534	0.1538	0.1764
(3) Bangkok, Thailand (BANGK)	0.1610	0.1603	0.1584	0.1642	0.2425	0.2411	0.2397	0.2451	0.1619	0.1614	0.1593	0.1659
(4) Washington, D.C. (DC)	0.1653	0.1652	0.1631	0.1606	0.2408	0.2409	0.2390	0.2349	0.1671	0.1679	0.1661	0.1630
(5) Alaska (NAK)	0.1227	0.1235	0.1231	0.1240	0.1947	0.1958	0.1950	0.1960	0.1207	0.1218	0.1211	0.1220
(6) Northern Australia, Tanami Desert (NAUS)	0.1087	0.0984	0.1050	0.1096	0.1783	0.1665	0.1746	0.1797	0.1064	0.0973	0.1033	0.1077
(7) Pyrenee Mountains (PYRNES)	0.1294	0.1509	0.1261	0.1284	0.2042	0.2290	0.2026	0.2036	0.1280	0.1533	0.1248	0.1268
(8) Spokane, Washington (SPOK)	0.1190	0.1261	0.1262	0.1305	0.1917	0.1988	0.1986	0.2028	0.1185	0.1258	0.1254	0.1298
(9) Tehran, Iran (TEHRAN)	0.1204	0.1051	0.0741	0.0887	0.1930	0.1761	0.1430	0.1593	0.1213	0.1062	0.0782	0.0911
(10) Xining, China (XINING)	0.1631	0.1693	0.1599	0.1506	0.2434	0.2501	0.2391	0.2267	0.1629	0.1718	0.1639	0.1514
	Elevation Angle = 10°											
	MRF				Goad				Exponential			
	0000	0600	1200	1800	0000	0600	1200	1800	0000	0600	1200	1800
(1) Ahaggar, Algeria (AHAGR)	0.0534	0.0563	0.0502	0.0470	0.0914	0.0944	0.0885	0.0845	0.0530	0.0557	0.0499	0.0470
(2) Amazon Forest (AMFOR)	0.0817	0.0818	0.0818	0.0921	0.1237	0.1233	0.1234	0.1353	0.0821	0.0821	0.0823	0.0940
(3) Bangkok, Thailand (BANGK)	0.0858	0.0854	0.0844	0.0873	0.1295	0.1289	0.1281	0.1309	0.0866	0.0863	0.0853	0.0886
(4) Washington, D.C. (DC)	0.0876	0.0876	0.0865	0.0852	0.1287	0.1287	0.1277	0.1257	0.0891	0.0895	0.0886	0.0870
(5) Alaska (NAK)	0.0660	0.0665	0.0662	0.0667	0.1050	0.1056	0.1052	0.1057	0.0651	0.0657	0.0653	0.0658
(6) Northern Australia, Tanami Desert (NAUS)	0.0586	0.0534	0.0568	0.0591	0.0966	0.0906	0.0947	0.0973	0.0576	0.0528	0.0559	0.0583
(7) Pyrenee Mountains (PYRNES)	0.0694	0.0806	0.0678	0.0689	0.1099	0.1227	0.1091	0.1096	0.0689	0.0820	0.0673	0.0683
(8) Spokane, Washington (SPOK)	0.0643	0.0679	0.0679	0.0701	0.1034	0.1070	0.1070	0.1091	0.0640	0.0678	0.0676	0.0699
(9) Tehran, Iran (TEHRAN)	0.0649	0.0570	0.0412	0.0487	0.1041	0.0955	0.0785	0.0868	0.0655	0.0575	0.0427	0.0496
(10) Xining, China (XINING)	0.0869	0.0901	0.0852	0.0804	0.1300	0.1334	0.1278	0.1214	0.0871	0.0917	0.0875	0.0811

Angle Error (degrees) **for Selected Areas-of-Interest**
MRF, Goad and Exponential Model for 15 November 1995
(0000, 0600, 1200 and 1800 Hours)

AOI	Elevation Angle = 0°											
	MRF				Goad				Exponential			
	0000	0600	1200	1800	0000	0600	1200	1800	0000	0600	1200	1800
(1) Ahaggar, Algeria (AHAGR)	0.2764	0.2830	0.2277	0.2409	0.5816	0.5878	0.5261	0.5322	0.2618	0.2672	0.2330	0.2356
(2) Amazon Forest (AMFOR)	0.4540	0.4473	0.4498	0.4200	0.9021	0.8902	0.8950	0.8763	0.4422	0.4350	0.4386	0.4225
(3) Bangkok, Thailand (BANGK)	0.4244	0.4380	0.4255	0.4208	0.8960	0.8936	0.8911	0.8849	0.4217	0.4221	0.4205	0.4193
(4) Washington, D.C. (DC)	0.2908	0.2825	0.2830	0.2829	0.6344	0.6161	0.6070	0.5979	0.2857	0.2796	0.2791	0.2760
(5) Alaska (NAK)	0.2881	0.2839	0.2920	0.2930	0.6015	0.5996	0.5989	0.5995	0.2797	0.2808	0.2810	0.2831
(6) Northern Australia, Tanami Desert (NAUS)	0.3370	0.3005	0.3500	0.3825	0.7466	0.7207	0.7653	0.7932	0.3497	0.3250	0.3505	0.3700
(7) Pyrenee Mountains (PYRNES)	0.3090	0.3030	0.3055	0.3086	0.6329	0.6336	0.6340	0.6362	0.2945	0.2917	0.2930	0.2953
(8) Spokane, Washington (SPOK)	0.3530	0.3499	0.3418	0.3449	0.7275	0.7189	0.7006	0.7048	0.3379	0.3375	0.3240	0.3232
(9) Tehran, Iran (TEHRAN)	0.2314	0.2207	0.2101	0.2403	0.5225	0.5144	0.5007	0.5264	0.2368	0.2316	0.2237	0.2387
(10) Xining, China (XINING)	0.2934	0.2590	0.2698	0.2841	0.6193	0.5606	0.5767	0.6027	0.2808	0.2474	0.2571	0.2723
	Elevation Angle = 1°											
	MRF				Goad				Exponential			
	0000	0600	1200	1800	0000	0600	1200	1800	0000	0600	1200	1800
(1) Ahaggar, Algeria (AHAGR)	0.2396	0.2446	0.2067	0.2127	0.4249	0.4293	0.3902	0.3942	0.2312	0.2355	0.2073	0.2094
(2) Amazon Forest (AMFOR)	0.3813	0.3758	0.3768	0.3601	0.6132	0.6061	0.6091	0.5978	0.3768	0.3711	0.3732	0.3618
(3) Bangkok, Thailand (BANGK)	0.3638	0.3688	0.3631	0.3598	0.6094	0.6080	0.6064	0.6028	0.3629	0.3629	0.3623	0.3606
(4) Washington, D.C. (DC)	0.2595	0.2531	0.2511	0.2496	0.4571	0.4468	0.4420	0.4365	0.2549	0.2498	0.2472	0.2430
(5) Alaska (NAK)	0.2535	0.2518	0.2548	0.2557	0.4390	0.4381	0.4382	0.4386	0.2457	0.2462	0.2464	0.2479
(6) Northern Australia, Tanami Desert (NAUS)	0.2954	0.2728	0.3031	0.3250	0.5210	0.5048	0.5317	0.5484	0.3038	0.2863	0.3055	0.3213
(7) Pyrenee Mountains (PYRNES)	0.2680	0.2645	0.2662	0.2683	0.4566	0.4566	0.4569	0.4583	0.2579	0.2558	0.2568	0.2586
(8) Spokane, Washington (SPOK)	0.3019	0.3010	0.2957	0.2973	0.5112	0.5063	0.4956	0.4979	0.2932	0.2927	0.2820	0.2817
(9) Tehran, Iran (TEHRAN)	0.2069	0.2000	0.1922	0.2141	0.3910	0.3852	0.3756	0.3932	0.2103	0.2060	0.1993	0.2120
(10) Xining, China (XINING)	0.2566	0.2262	0.2355	0.2487	0.4488	0.4117	0.4219	0.4379	0.2471	0.2194	0.2274	0.2398
	Elevation Angle = 3°											
	MRF				Goad				Exponential			
	0000	0600	1200	1800	0000	0600	1200	1800	0000	0600	1200	1800
(1) Ahaggar, Algeria (AHAGR)	0.1513	0.1537	0.1355	0.1373	0.2536	0.2561	0.2359	0.2380	0.1479	0.1502	0.1341	0.1352
(2) Amazon Forest (AMFOR)	0.2286	0.2257	0.2262	0.2195	0.3452	0.3417	0.3433	0.3376	0.2306	0.2275	0.2284	0.2227
(3) Bangkok, Thailand (BANGK)	0.2226	0.2234	0.2218	0.2201	0.3432	0.3425	0.3417	0.3400	0.2241	0.2241	0.2239	0.2227
(4) Washington, D.C. (DC)	0.1653	0.1617	0.1600	0.1585	0.2696	0.2647	0.2626	0.2599	0.1625	0.1593	0.1575	0.1547
(5) Alaska (NAK)	0.1604	0.1599	0.1604	0.1607	0.2613	0.2610	0.2612	0.2615	0.1560	0.1561	0.1561	0.1568
(6) Northern Australia, Tanami Desert (NAUS)	0.1866	0.1765	0.1898	0.1999	0.3000	0.2916	0.3051	0.3133	0.1904	0.1814	0.1919	0.2007
(7) Pyrenee Mountains (PYRNES)	0.1676	0.1662	0.1670	0.1679	0.2696	0.2695	0.2696	0.2703	0.1632	0.1622	0.1627	0.1637
(8) Spokane, Washington (SPOK)	0.1860	0.1854	0.1820	0.1829	0.2958	0.2935	0.2883	0.2893	0.1835	0.1831	0.1772	0.1774
(9) Tehran, Iran (TEHRAN)	0.1349	0.1319	0.1279	0.1379	0.2375	0.2343	0.2290	0.2386	0.1350	0.1325	0.1289	0.1360
(10) Xining, China (XINING)	0.1611	0.1447	0.1496	0.1569	0.2660	0.2468	0.2520	0.2602	0.1564	0.1412	0.1457	0.1527
	Elevation Angle = 5°											
	MRF				Goad				Exponential			
	0000	0600	1200	1800	0000	0600	1200	1800	0000	0600	1200	1800
(1) Ahaggar, Algeria (AHAGR)	0.1046	0.1061	0.0946	0.0956	0.1750	0.1766	0.1636	0.1650	0.1026	0.1041	0.0933	0.0941
(2) Amazon Forest (AMFOR)	0.1547	0.1529	0.1532	0.1492	0.2334	0.2312	0.2322	0.2286	0.1571	0.1551	0.1556	0.1519
(3) Bangkok, Thailand (BANGK)	0.1515	0.1518	0.1509	0.1499	0.2322	0.2317	0.2312	0.2301	0.1531	0.1530	0.1529	0.1521
(4) Washington, D.C. (DC)	0.1141	0.1117	0.1106	0.1095	0.1851	0.1820	0.1807	0.1790	0.1122	0.1100	0.1088	0.1069
(5) Alaska (NAK)	0.1107	0.1105	0.1107	0.1109	0.1799	0.1798	0.1800	0.1801	0.1077	0.1078	0.1078	0.1083
(6) Northern Australia, Tanami Desert (NAUS)	0.1285	0.1222	0.1304	0.1365	0.2045	0.1991	0.2078	0.2130	0.1308	0.1249	0.1319	0.1376
(7) Pyrenee Mountains (PYRNES)	0.1153	0.1145	0.1149	0.1156	0.1852	0.1851	0.1852	0.1857	0.1127	0.1120	0.1123	0.1130
(8) Spokane, Washington (SPOK)	0.1273	0.1268	0.1245	0.1251	0.2019	0.2005	0.1971	0.1978	0.1261	0.1258	0.1220	0.1221
(9) Tehran, Iran (TEHRAN)	0.0944	0.0925	0.0899	0.0961	0.1648	0.1627	0.1592	0.1655	0.0938	0.0922	0.0897	0.0945
(10) Xining, China (XINING)	0.1112	0.1005	0.1037	0.1084	0.1831	0.1706	0.1740	0.1793	0.1082	0.0980	0.1010	0.1057
	Elevation Angle = 10°											
	MRF				Goad				Exponential			
	0000	0600	1200	1800	0000	0600	1200	1800	0000	0600	1200	1800
(1) Ahaggar, Algeria (AHAGR)	0.0566	0.0574	0.0515	0.0520	0.0950	0.0958	0.0891	0.0898	0.0556	0.0564	0.0507	0.0511
(2) Amazon Forest (AMFOR)	0.0824	0.0815	0.0817	0.0797	0.1249	0.1238	0.1243	0.1224	0.0840	0.0830	0.0833	0.0813
(3) Bangkok, Thailand (BANGK)	0.0810	0.0810	0.0807	0.0801	0.1242	0.1240	0.1237	0.1232	0.0820	0.0820	0.0819	0.0815
(4) Washington, D.C. (DC)	0.0616	0.0604	0.0598	0.0592	0.1000	0.0984	0.0978	0.0970	0.0606	0.0594	0.0588	0.0578
(5) Alaska (NAK)	0.0598	0.0597	0.0598	0.0599	0.0974	0.0974	0.0975	0.0975	0.0582	0.0583	0.0582	0.0585
(6) Northern Australia, Tanami Desert (NAUS)	0.0692	0.0660	0.0701	0.0732	0.1101	0.1073	0.1117	0.1144	0.0704	0.0673	0.0710	0.0739
(7) Pyrenee Mountains (PYRNES)	0.0622	0.0618	0.0620	0.0623	0.1001	0.1001	0.1001	0.1004	0.0608	0.0605	0.0607	0.0610
(8) Spokane, Washington (SPOK)	0.0684	0.0681	0.0668	0.0671	0.1087	0.1080	0.1062	0.1066	0.0679	0.0677	0.0657	0.0658
(9) Tehran, Iran (TEHRAN)	0.0514	0.0505	0.0491	0.0522	0.0897	0.0887	0.0869	0.0901	0.0509	0.0501	0.0488	0.0513
(10) Xining, China (XINING)	0.0601	0.0546	0.0562	0.0586	0.0991	0.0927	0.0944	0.0971	0.0585	0.0532	0.0548	0.0572

Appendix J

TIME DELAYS AND ANGLE ERRORS FOR SEASONS AND HOURS/ANGLES BY MODELS

Time delays and angle errors are compared for 10 areas of interest with seasons and hours by models from the horizon to 10° elevation angles.

Time Delay (ns) for Selected Areas-of-Interest
MRF, Goad and Exponential Model for 15 February 1995
(0000, 0600, 1200 and 1800 Hours)

Elevation Angle = 0°

AOI	00 00				06 00				12 00				18 00			
	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	334.0	284.9	288.8	336.3	334.0	288.8	291.1	341.4	334.0	271.8	280.8	325.1	334.0	272.6	280.9	324.2
(2) Amazon Forest (AMFOR)	431.7	330.0	338.6	424.6	430.3	329.6	337.4	423.6	430.9	329.7	337.5	423.7	431.5	330.1	339.5	424.0
(3) Bangkok, Thailand (BANGK)	430.0	329.3	338.2	418.8	415.8	321.6	331.5	408.7	421.9	325.1	334.3	413.9	425.6	326.9	336.2	416.4
(4) Washington, D.C. (DC)	337.2	294.1	291.3	341.0	340.3	295.8	292.2	343.7	350.3	299.6	296.2	351.9	362.3	302.8	302.5	363.1
(5) Alaska (NAK)	342.2	296.1	292.8	347.1	342.7	296.5	293.1	347.8	341.4	295.9	292.6	346.8	342.1	296.5	293.0	347.7
(6) Northern Australia, Tanami Desert (NAUS)	400.4	313.8	324.5	395.8	368.7	295.7	309.3	366.8	382.0	303.7	316.0	378.7	397.3	311.2	321.3	392.4
(7) Pyrenee Mountains (PYRNES)	345.1	297.1	294.2	349.8	345.1	297.2	294.6	350.1	345.5	296.6	294.4	350.4	346.8	297.7	295.3	351.7
(8) Spokane, Washington (SPOK)	333.3	296.3	289.3	337.4	338.6	301.1	292.4	343.0	334.7	296.5	289.6	339.1	337.1	295.3	290.7	340.7
(9) Tehran, Iran (TEHRAN)	364.4	302.5	305.0	367.2	365.6	303.2	305.6	368.4	366.3	302.6	305.8	368.5	365.7	303.5	306.0	368.7
(10) Xining, China (XINING)	348.3	300.3	298.5	351.3	339.4	288.8	291.8	343.3	339.9	289.6	292.2	344.0	348.7	297.0	297.6	352.5

Elevation Angle = 1°

AOI	00 00				06 00				12 00				18 00			
	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	233.0	199.4	203.1	235.9	233.2	201.9	204.3	239.1	226.5	190.4	198.9	229.9	226.7	191.0	198.9	229.4
(2) Amazon Forest (AMFOR)	284.7	221.9	230.4	281.0	283.9	221.9	229.7	280.7	283.8	222.0	229.8	280.7	283.9	221.8	231.0	280.4
(3) Bangkok, Thailand (BANGK)	280.9	221.3	230.2	274.7	276.5	216.9	226.6	271.1	279.3	218.9	228.0	273.1	281.3	220.0	229.1	274.0
(4) Washington, D.C. (DC)	235.5	206.6	204.2	238.6	237.9	207.8	204.6	240.6	244.6	209.7	206.7	245.3	251.4	210.2	210.2	251.2
(5) Alaska (NAK)	235.8	207.1	204.1	241.7	236.0	207.3	204.3	242.0	235.0	206.9	204.1	241.6	235.2	207.3	204.3	242.1
(6) Northern Australia, Tanami Desert (NAUS)	268.2	212.3	222.7	266.9	255.1	201.4	214.3	253.1	261.4	206.2	218.0	259.6	268.0	211.0	220.7	266.3
(7) Pyrenee Mountains (PYRNES)	237.4	207.8	205.2	243.0	237.6	207.7	205.5	243.2	237.7	207.3	205.4	243.5	238.2	208.0	205.9	244.2
(8) Spokane, Washington (SPOK)	231.4	208.6	202.1	235.1	234.2	211.7	203.8	238.4	232.1	208.4	202.1	236.2	233.5	206.7	202.5	237.2
(9) Tehran, Iran (TEHRAN)	249.5	209.0	211.5	253.6	250.3	209.4	211.9	254.1	251.1	208.6	211.9	253.5	250.6	209.5	212.1	253.9
(10) Xining, China (XINING)	240.9	209.7	208.3	244.0	235.6	201.4	204.3	240.0	236.1	202.0	204.6	240.6	241.2	206.9	207.7	245.4

Elevation Angle = 3°

AOI	00 00				06 00				12 00				18 00			
	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	132.7	116.7	119.6	135.0	132.1	118.1	120.0	136.5	130.0	111.6	118.0	132.8	130.2	112.0	117.9	132.5
(2) Amazon Forest (AMFOR)	153.6	126.1	132.8	150.2	153.3	126.3	132.4	150.3	153.1	126.3	132.5	150.2	153.1	126.0	133.1	149.8
(3) Bangkok, Thailand (BANGK)	150.9	125.8	132.7	145.5	150.1	123.6	131.1	145.4	150.9	124.6	131.7	145.4	151.9	125.2	132.2	145.7
(4) Washington, D.C. (DC)	133.5	121.3	119.6	136.2	135.0	122.0	119.7	137.3	138.4	122.8	120.7	139.2	141.4	122.4	122.6	141.4
(5) Alaska (NAK)	132.5	121.2	119.2	137.1	132.5	121.3	119.2	137.2	132.0	121.1	119.1	137.1	132.0	121.3	119.2	137.2
(6) Northern Australia, Tanami Desert (NAUS)	147.0	121.3	129.2	145.6	143.1	115.6	125.4	141.4	145.7	118.1	127.1	144.2	147.8	120.7	128.2	146.2
(7) Pyrenee Mountains (PYRNES)	133.2	121.6	119.8	137.5	133.3	121.5	120.0	137.7	133.3	121.3	120.0	137.8	133.5	121.6	120.2	138.1
(8) Spokane, Washington (SPOK)	130.5	122.6	118.0	133.5	131.5	124.4	118.7	135.0	130.6	122.4	117.8	134.1	131.1	121.0	118.1	134.2
(9) Tehran, Iran (TEHRAN)	139.3	121.2	123.3	142.4	139.6	121.4	123.5	142.5	139.9	120.8	123.5	141.7	139.6	121.5	123.6	142.1
(10) Xining, China (XINING)	135.5	122.6	121.7	137.9	133.2	117.6	119.9	136.7	133.6	118.0	120.1	137.2	135.8	120.7	121.5	139.1

Elevation Angle = 5°

AOI	00 00				06 00				12 00				18 00			
	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	89.5	79.8	82.0	91.2	89.0	80.7	82.2	92.1	87.8	76.3	81.1	90.0	88.0	76.5	81.0	89.8
(2) Amazon Forest (AMFOR)	101.9	85.5	90.5	99.1	101.8	85.6	90.2	99.2	101.7	85.6	90.3	99.1	101.6	85.3	90.7	98.7
(3) Bangkok, Thailand (BANGK)	100.1	85.2	90.4	95.6	99.8	83.8	89.5	96.0	100.2	84.5	89.8	95.8	100.8	84.8	90.2	95.9
(4) Washington, D.C. (DC)	89.8	83.0	81.7	91.9	90.8	83.5	81.8	92.6	93.0	83.9	82.4	93.8	94.8	83.5	83.7	94.9
(5) Alaska (NAK)	88.9	82.8	81.4	92.3	88.9	82.9	81.4	92.3	88.6	82.8	81.3	92.3	88.5	82.9	81.4	92.4
(6) Northern Australia, Tanami Desert (NAUS)	98.0	82.3	88.3	96.6	95.9	78.5	85.9	94.6	97.6	80.2	87.0	96.3	98.7	81.9	87.6	97.2
(7) Pyrenee Mountains (PYRNES)	89.3	83.1	81.8	92.5	89.4	83.0	82.0	92.6	89.4	82.9	82.0	92.7	89.5	83.1	82.1	92.9
(8) Spokane, Washington (SPOK)	87.5	83.9	80.5	90.0	88.2	85.1	80.9	90.9	87.6	83.7	80.4	90.3	87.9	82.7	80.6	90.2
(9) Tehran, Iran (TEHRAN)	93.3	82.6	84.3	95.5	93.5	82.8	84.4	95.5	93.6	82.3	84.4	94.9	93.4	82.8	84.5	95.2
(10) Xining, China (XINING)	90.9	83.8	83.1	92.8	89.6	80.3	82.1	92.2	89.8	80.6	82.2	92.6	91.2	82.4	83.1	93.7

Elevation Angle = 10°

AOI	00 00				06 00				12 00				18 00			
	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	48.0	43.3	44.6	49.0	47.7	43.8	44.7	49.5	47.2	41.4	44.2	48.5	47.3	41.5	44.2	48.4
(2) Amazon Forest (AMFOR)	54.2	46.0	49.1	52.4	54.1	46.1	48.9	52.4	54.0	46.1	49.0	52.4	54.0	46.0	49.2	52.2
(3) Bangkok, Thailand (BANGK)	53.2	45.9	49.0	50.5	53.1	45.2	48.6	50.8	53.3	45.5	48.7	50.6	53.6	45.7	48.9	50.6
(4) Washington, D.C. (DC)	48.1	45.1	44.4	49.3	48.7	45.3	44.4	49.7	49.8	45.5	44.7	50.3	50.7	45.2	45.4	50.8
(5) Alaska (NAK)	47.6	44.9	44.1	49.5	47.6	45.0	44.1	49.5	47.4	44.9	44.1	49.5	47.4	45.0	44.1	49.5
(6) Northern Australia, Tanami Desert (NAUS)	52.3	44.4	48.0	51.3	51.3	42.4	46.8	50.5	52.1	43.3	47.3	51.3	52.6	44.2	47.6	51.7
(7) Pyrenee Mountains (PYRNES)	47.8	45.1	44.4	49.6	47.8	45.0	44.5	49.6	47.8	45.0	44.5	49.7	47.9	45.1	44.5	49.8
(8) Spokane, Washington (SPOK)	46.8	45.6	43.6	48.3	47.1	46.2	43.8	48.7	46.8	45.5	43.5	48.4	47.0	44.9	43.7	48.4
(9) Tehran, Iran (TEHRAN)	49.9	44.7	45.7	51.1	49.9	44.8	45.8	51.1	50.0	44.6	45.8	50.7	49.9	44.8	45.8	50.9
(10) Xining, China (XINING)	48.7	45.4	45.1	49.7	48.0	43.5	44.6	49.5	48.1	43.7	44.7	49.7	48.8	44.7	45.1	50.2

Time Delay (ns) for Selected Areas-of-Interest
MRF, Goad and Exponential Model for 15 May 1995
(0000, 0600, 1200 and 1800 Hours)

AOI	Elevation Angle = 0°															
	00 00				06 00				12 00				18 00			
	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	334.0	266.3	275.2	315.5	334.0	271.2	278.2	320.7	334.0	255.2	269.6	305.8	334.0	253.8	267.7	302.5
(2) Amazon Forest (AMFOR)	444.9	335.2	343.9	435.3	440.5	333.7	341.7	432.8	439.6	333.1	341.2	432.5	441.8	333.3	342.7	434.2
(3) Bangkok, Thailand (BANGK)	442.8	333.4	343.0	437.5	448.9	336.3	346.0	440.7	437.9	330.9	341.0	431.9	456.8	339.8	349.3	446.2
(4) Washington, D.C. (DC)	411.7	321.9	328.0	406.5	402.3	318.7	323.7	397.9	395.4	315.6	320.2	391.8	384.5	309.1	315.7	383.9
(5) Alaska (NAK)	347.5	298.7	296.7	352.6	348.2	299.1	297.1	353.1	348.0	299.3	296.9	352.6	348.4	299.5	297.1	353.0
(6) Northern Australia, Tanami Desert (NAUS)	368.3	295.7	303.4	365.4	361.0	292.4	302.3	358.6	372.2	300.5	308.3	368.8	380.7	305.9	311.8	377.8
(7) Pyrenee Mountains (PYRNES)	358.1	299.7	302.0	361.7	354.3	299.0	301.9	358.1	352.0	297.6	300.6	355.8	356.3	298.4	301.1	360.1
(8) Spokane, Washington (SPOK)	364.5	298.3	304.7	368.2	387.8	312.5	316.6	389.0	366.9	302.1	305.6	369.4	375.7	306.9	311.1	377.8
(9) Tehran, Iran (TEHRAN)	378.2	305.5	311.2	378.8	368.8	297.1	306.4	369.4	362.8	290.9	302.4	361.8	376.8	301.7	310.6	375.5
(10) Xining, China (XINING)	358.7	296.9	302.2	362.4	325.0	270.4	281.9	328.5	343.1	281.4	291.8	346.3	370.6	300.8	307.6	372.6
	Elevation Angle = 1°															
	00 00				06 00				12 00				18 00			
	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	221.7	187.2	195.6	224.7	223.9	190.6	197.1	227.8	218.0	179.3	192.7	218.9	216.6	178.5	191.6	216.7
(2) Amazon Forest (AMFOR)	291.6	224.7	233.4	285.9	290.0	224.1	232.0	286.0	288.8	223.8	231.9	286.5	289.9	223.4	232.7	286.9
(3) Bangkok, Thailand (BANGK)	291.3	223.4	232.9	290.2	291.4	224.9	234.5	290.4	287.3	221.8	231.8	286.3	296.1	226.9	236.4	291.4
(4) Washington, D.C. (DC)	270.3	218.1	224.3	271.1	265.2	216.7	221.8	266.6	262.1	215.2	219.8	264.3	257.8	211.1	217.6	260.4
(5) Alaska (NAK)	239.1	208.2	206.5	244.9	239.5	208.4	206.8	245.1	239.5	208.8	206.7	244.9	239.8	208.8	206.9	245.1
(6) Northern Australia, Tanami Desert (NAUS)	255.4	203.6	211.1	251.6	252.1	201.0	210.5	248.0	258.1	206.3	213.8	253.3	261.6	209.7	215.6	258.2
(7) Pyrenee Mountains (PYRNES)	245.1	207.3	209.7	250.2	243.3	206.8	209.7	248.3	242.1	205.9	209.0	247.1	244.3	206.5	209.2	249.4
(8) Spokane, Washington (SPOK)	249.9	205.0	211.3	254.0	262.2	213.3	217.6	264.7	251.3	207.9	211.5	254.2	254.9	210.3	214.6	257.9
(9) Tehran, Iran (TEHRAN)	258.3	209.4	215.0	259.6	253.8	203.7	212.7	254.2	251.6	199.6	210.5	250.3	258.4	206.4	215.0	256.8
(10) Xining, China (XINING)	246.5	205.0	210.2	250.9	228.2	188.1	199.0	232.3	238.9	194.4	204.3	242.9	253.2	206.3	213.0	256.2
	Elevation Angle = 3°															
	00 00				06 00				12 00				18 00			
	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	128.4	109.9	116.3	130.8	129.1	111.9	116.9	132.1	127.1	105.2	115.4	128.2	126.5	104.9	114.8	127.1
(2) Amazon Forest (AMFOR)	156.5	127.4	134.2	151.6	156.2	127.3	133.5	152.6	155.6	127.2	133.5	153.3	155.8	126.7	133.9	153.0
(3) Bangkok, Thailand (BANGK)	156.6	126.7	134.0	155.3	155.6	127.4	134.8	154.4	154.4	125.8	133.5	153.1	157.7	128.4	135.7	153.5
(4) Washington, D.C. (DC)	146.2	124.7	129.6	146.3	144.1	124.2	128.4	144.6	143.2	123.6	127.4	144.4	141.7	121.4	126.5	143.2
(5) Alaska (NAK)	134.0	121.6	120.5	138.6	134.2	121.7	120.7	138.6	134.3	122.0	120.6	138.5	134.5	122.0	120.7	138.6
(6) Northern Australia, Tanami Desert (NAUS)	143.7	117.8	123.6	140.8	142.5	116.2	123.5	139.5	145.0	119.1	124.9	141.3	145.9	121.0	125.6	143.2
(7) Pyrenee Mountains (PYRNES)	137.0	120.4	122.4	140.8	136.3	120.0	122.4	140.1	135.9	119.6	122.1	139.7	136.7	119.9	122.2	140.6
(8) Spokane, Washington (SPOK)	139.3	118.5	123.4	142.3	144.2	122.7	126.2	145.8	139.9	120.3	123.2	142.0	140.7	121.3	124.7	142.8
(9) Tehran, Iran (TEHRAN)	143.6	120.8	125.2	144.4	141.9	117.5	124.4	142.2	141.6	115.2	123.5	140.7	143.9	118.9	125.5	142.6
(10) Xining, China (XINING)	138.1	118.9	122.9	141.3	130.6	109.6	117.9	133.9	135.4	112.8	120.3	138.5	140.9	119.0	124.2	143.0
	Elevation Angle = 5°															
	00 00				06 00				12 00				18 00			
	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	87.0	75.2	80.0	89.0	87.4	76.6	80.3	89.7	86.4	72.0	79.6	87.4	86.0	71.8	79.2	86.6
(2) Amazon Forest (AMFOR)	103.7	86.3	91.4	99.7	103.6	86.2	90.9	100.6	103.2	86.1	90.9	101.1	103.3	85.8	91.3	100.8
(3) Bangkok, Thailand (BANGK)	103.8	85.8	91.3	102.4	103.0	86.2	91.8	101.6	102.4	85.2	91.0	101.0	104.3	86.8	92.4	100.7
(4) Washington, D.C. (DC)	97.2	84.7	88.4	96.7	95.9	84.4	87.5	95.8	95.5	84.0	86.9	95.9	94.6	82.5	86.4	95.4
(5) Alaska (NAK)	89.9	83.1	82.3	93.2	90.0	83.1	82.4	93.2	90.0	83.3	82.3	93.2	90.2	83.3	82.4	93.2
(6) Northern Australia, Tanami Desert (NAUS)	96.4	80.3	84.6	94.4	95.7	79.1	84.6	93.6	97.2	81.1	85.5	94.6	97.6	82.3	85.8	95.7
(7) Pyrenee Mountains (PYRNES)	91.8	82.1	83.6	94.5	91.4	81.8	83.7	94.1	91.2	81.6	83.5	93.9	91.7	81.8	83.5	94.4
(8) Spokane, Washington (SPOK)	93.3	80.7	84.4	95.4	96.2	83.4	86.1	97.2	93.6	81.9	84.2	95.0	93.9	82.5	85.2	95.3
(9) Tehran, Iran (TEHRAN)	96.0	82.2	85.6	96.6	95.0	80.0	85.2	95.2	95.0	78.4	84.7	94.4	96.3	80.8	85.8	95.2
(10) Xining, China (XINING)	92.6	81.0	84.1	94.9	88.2	74.9	81.1	90.7	91.1	76.9	82.6	93.4	94.3	81.0	85.0	95.7
	Elevation Angle = 10°															
	00 00				06 00				12 00				18 00			
	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	46.9	40.8	43.7	48.0	47.1	41.6	43.8	48.4	46.6	39.1	43.6	47.2	46.4	39.0	43.3	46.8
(2) Amazon Forest (AMFOR)	55.1	46.5	49.6	52.6	55.0	46.4	49.3	53.2	54.8	46.4	49.3	53.5	54.9	46.2	49.5	53.3
(3) Bangkok, Thailand (BANGK)	55.1	46.2	49.5	54.2	54.7	46.4	49.8	53.6	54.4	45.9	49.3	53.4	55.3	46.7	50.1	53.1
(4) Washington, D.C. (DC)	51.7	45.7	47.9	51.3	51.1	45.6	47.5	50.8	50.9	45.4	47.1	51.0	50.4	44.6	46.9	50.8
(5) Alaska (NAK)	48.0	45.0	44.6	50.0	48.1	45.1	44.7	50.0	48.1	45.2	44.7	49.9	48.2	45.2	44.7	50.0
(6) Northern Australia, Tanami Desert (NAUS)	51.6	43.4	46.0	50.4	51.2	42.8	46.1	50.1	52.0	43.8	46.5	50.5	52.2	44.5	46.6	51.0
(7) Pyrenee Mountains (PYRNES)	49.1	44.4	45.4	50.6	48.9	44.3	45.4	50.4	48.8	44.2	45.3	50.3	49.0	44.3	45.4	50.5
(8) Spokane, Washington (SPOK)	49.8	43.7	45.9	51.0	51.2	45.1	46.7	51.7	50.0	44.3	45.7	50.8	50.1	44.6	46.2	50.8
(9) Tehran, Iran (TEHRAN)	51.2	44.4	46.5	51.5	50.8	43.3	46.3	50.9	50.8	42.4	46.1	50.5	51.4	43.7	46.7	50.8
(10) Xining, China (XINING)	49.5	43.9	45.7	50.8	47.4	40.6	44.2	48.8	48.9	41.6	45.0	50.1	50.4	43.8	46.2	51.1

Time Delay (ns) for Selected Areas-of-Interest

MRF, Goad and Exponential Model for 15 August 1995

(0000, 0600, 1200 and 1800 Hours)

AOI	Elevation Angle = 0°															
	00 00				06 00				12 00				18 00			
	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	334.0	271.6	282.5	327.5	334.0	278.2	287.2	335.7	334.0	262.7	278.2	318.7	334.0	255.9	271.2	307.8
(2) Amazon Forest (AMFOR)	423.4	326.1	335.2	418.2	423.9	326.3	334.3	418.4	423.9	326.5	334.8	417.5	416.7	323.6	333.8	411.5
(3) Bangkok, Thailand (BANGK)	449.3	335.5	344.9	442.7	446.3	334.1	343.9	439.3	443.7	332.8	342.5	436.6	454.7	337.9	347.3	444.7
(4) Washington, D.C. (DC)	444.4	333.7	344.2	433.8	444.9	335.1	343.9	433.1	439.7	334.1	342.1	428.5	432.4	329.2	339.3	422.7
(5) Alaska (NAK)	364.7	302.8	303.7	366.6	366.3	303.6	304.6	368.0	364.7	303.1	304.1	366.5	365.7	304.1	305.0	367.8
(6) Northern Australia, Tanami Desert (NAUS)	336.7	287.8	291.7	340.6	322.7	272.4	281.6	325.7	332.2	283.2	288.4	335.7	338.3	289.2	292.4	341.5
(7) Pyrenee Mountains (PYRNES)	376.8	306.5	312.4	377.2	373.3	306.0	312.5	374.1	371.2	304.7	311.3	372.2	374.7	305.6	312.0	375.5
(8) Spokane, Washington (SPOK)	359.8	294.7	300.8	360.4	368.6	301.9	306.1	368.6	367.8	302.6	305.9	368.5	373.1	304.4	309.4	373.7
(9) Tehran, Iran (TEHRAN)	363.2	291.9	303.0	361.6	338.5	274.1	288.9	336.8	295.9	242.8	260.0	288.8	317.7	260.4	274.3	313.8
(10) Xining, China (XINING)	450.5	337.3	345.5	447.3	462.4	340.9	351.6	455.2	440.9	331.8	342.5	432.7	418.1	322.7	332.1	415.[illegible]

AOI	Elevation Angle = 1°															
	00 00				06 00				12 00				18 00			
	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	229.8	189.3	199.6	231.2	233.3	193.5	202.1	235.8	226.0	183.0	197.6	226.5	220.8	179.3	193.6	219.9
(2) Amazon Forest (AMFOR)	278.7	219.6	228.6	279.0	278.6	220.0	227.9	279.0	278.3	220.1	228.3	278.0	276.0	217.9	227.9	275.0
(3) Bangkok, Thailand (BANGK)	296.4	224.6	233.9	294.3	294.4	223.8	233.4	291.9	293.1	223.0	232.6	290.9	297.2	226.0	235.2	293.6
(4) Washington, D.C. (DC)	287.9	223.4	233.8	284.0	288.2	224.7	233.5	282.8	286.1	224.4	232.4	280.1	282.1	221.1	231.1	277.3
(5) Alaska (NAK)	249.5	209.6	210.7	253.2	250.6	209.9	211.2	253.8	249.4	209.7	210.9	252.8	250.0	210.3	211.4	253.5
(6) Northern Australia, Tanami Desert (NAUS)	233.9	200.8	204.6	238.1	227.8	190.5	199.2	229.7	232.1	197.8	202.9	235.4	234.7	201.8	204.8	238.3
(7) Pyrenee Mountains (PYRNES)	256.0	210.0	215.9	258.5	254.5	209.6	215.9	256.8	253.6	208.8	215.3	255.9	254.9	209.3	215.7	257.6
(8) Spokane, Washington (SPOK)	248.5	203.1	209.1	249.5	252.4	207.5	211.8	253.0	251.7	208.2	211.6	253.1	254.4	208.6	213.6	255.5
(9) Tehran, Iran (TEHRAN)	250.9	200.2	210.8	249.1	237.7	189.2	203.2	235.8	215.6	171.0	187.1	208.1	227.4	181.9	195.0	223.1
(10) Xining, China (XINING)	297.7	226.0	234.1	297.6	304.2	227.2	237.8	299.2	292.6	222.2	232.8	285.2	279.1	217.8	227.0	277.6

AOI	Elevation Angle = 3°															
	00 00				06 00				12 00				18 00			
	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	132.0	110.5	118.4	133.2	133.2	112.8	119.4	135.1	130.9	106.8	117.8	131.5	128.8	105.0	115.8	128.4
(2) Amazon Forest (AMFOR)	150.7	125.0	131.9	150.5	150.6	125.3	131.5	150.4	150.4	125.4	131.8	149.6	149.8	124.0	131.7	148.6
(3) Bangkok, Thailand (BANGK)	159.8	127.3	134.5	157.9	158.8	126.8	134.3	156.6	158.5	126.5	133.9	156.5	159.5	127.9	135.1	156.4
(4) Washington, D.C. (DC)	153.8	126.6	134.6	150.2	154.0	127.5	134.3	149.1	153.2	127.5	133.8	147.9	151.4	125.6	133.3	147.0
(5) Alaska (NAK)	139.5	121.7	122.8	142.2	140.0	121.9	123.0	142.3	139.3	121.8	122.9	141.9	139.6	122.1	123.2	142.1
(6) Northern Australia, Tanami Desert (NAUS)	132.6	117.4	120.3	135.6	130.7	111.5	118.1	132.3	132.2	115.7	119.6	134.6	133.0	117.9	120.3	135.4
(7) Pyrenee Mountains (PYRNES)	142.2	121.1	125.7	143.9	141.7	120.8	125.8	143.2	141.4	120.4	125.5	143.0	141.7	120.7	125.7	143.6
(8) Spokane, Washington (SPOK)	139.6	117.7	122.3	140.4	140.5	120.0	123.4	140.9	140.0	120.4	123.2	141.0	140.8	120.3	124.3	141.6
(9) Tehran, Iran (TEHRAN)	141.0	115.5	123.6	139.4	135.7	109.7	120.2	134.3	127.5	100.5	112.7	122.6	132.4	106.4	116.3	129.5
(10) Xining, China (XINING)	160.3	128.1	134.5	160.0	162.8	128.3	136.4	158.6	158.0	126.0	134.1	151.8	151.8	124.2	131.3	150.2

AOI	Elevation Angle = 5°															
	00 00				06 00				12 00				18 00			
	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	89.3	75.5	81.4	90.2	89.9	77.0	82.0	91.2	88.7	73.0	81.2	89.3	87.4	71.8	79.9	87.4
(2) Amazon Forest (AMFOR)	100.2	84.7	90.0	99.5	100.0	85.0	89.7	99.4	99.9	85.0	89.9	98.9	99.7	84.1	89.9	98.3
(3) Bangkok, Thailand (BANGK)	106.0	86.1	91.6	104.2	105.3	85.8	91.5	103.3	105.1	85.6	91.2	103.4	105.7	86.6	92.0	103.0
(4) Washington, D.C. (DC)	101.9	85.7	91.7	98.7	102.0	86.3	91.5	97.9	101.5	86.3	91.1	97.1	100.4	85.1	90.9	96.6
(5) Alaska (NAK)	93.5	83.0	83.9	95.4	93.9	83.1	84.0	95.5	93.4	83.1	84.0	95.2	93.5	83.2	84.1	95.3
(6) Northern Australia, Tanami Desert (NAUS)	89.4	80.2	82.4	91.5	88.3	76.2	81.2	89.6	89.2	79.0	82.0	90.9	89.6	80.5	82.4	91.3
(7) Pyrenee Mountains (PYRNES)	95.2	82.4	85.9	96.2	94.9	82.2	86.0	95.9	94.8	81.9	85.8	95.7	94.9	82.1	85.9	96.1
(8) Spokane, Washington (SPOK)	93.6	80.2	83.7	94.2	94.0	81.7	84.3	94.2	93.7	82.0	84.1	94.3	94.1	81.8	84.9	94.5
(9) Tehran, Iran (TEHRAN)	94.6	78.6	84.7	93.4	91.6	74.8	82.7	90.6	86.9	68.8	78.0	83.7	89.8	72.7	80.2	88.0
(10) Xining, China (XINING)	106.3	86.7	91.6	105.7	107.7	86.7	92.9	104.3	104.8	85.3	91.4	99.9	101.0	84.2	89.6	99.5

AOI	Elevation Angle = 10°															
	00 00				06 00				12 00				18 00			
	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	48.0	40.9	44.4	48.6	48.3	41.8	44.7	49.1	47.8	39.6	44.4	48.2	47.1	39.0	43.7	47.2
(2) Amazon Forest (AMFOR)	53.3	45.6	48.8	52.7	53.2	45.8	48.6	52.7	53.2	45.8	48.7	52.4	53.0	45.3	48.8	52.1
(3) Bangkok, Thailand (BANGK)	56.3	46.4	49.7	55.2	56.0	46.2	49.6	54.7	55.9	46.1	49.5	54.7	56.1	46.6	49.9	54.4
(4) Washington, D.C. (DC)	54.1	46.1	49.8	52.1	54.2	46.5	49.6	51.6	53.9	46.5	49.4	51.2	53.4	45.8	49.3	51.[illegible]
(5) Alaska (NAK)	50.0	44.9	45.5	51.1	50.2	45.0	45.6	51.1	50.0	45.0	45.6	50.9	50.0	45.1	45.6	51.[illegible]
(6) Northern Australia, Tanami Desert (NAUS)	48.0	43.5	44.8	49.1	47.5	41.4	44.3	48.2	47.9	42.9	44.6	48.9	48.1	43.7	44.8	49.[illegible]
(7) Pyrenee Mountains (PYRNES)	50.9	44.5	46.6	51.4	50.7	44.4	46.7	51.2	50.7	44.3	46.6	51.2	50.7	44.4	46.7	51.3
(8) Spokane, Washington (SPOK)	50.1	43.4	45.5	50.4	50.2	44.2	45.8	50.3	50.0	44.4	45.7	50.4	50.2	44.2	46.1	50.4
(9) Tehran, Iran (TEHRAN)	50.7	42.5	46.1	49.9	49.2	40.5	45.1	48.6	47.0	37.4	42.8	45.3	48.4	39.4	43.8	47.5
(10) Xining, China (XINING)	56.4	46.7	49.6	55.9	57.1	46.7	50.3	55.0	55.6	45.9	49.6	52.8	53.7	45.4	48.6	52.8

Time Delay (ns) for Selected Areas-of-Interest
MRF, Goad and Exponential Model for 15 November 1995
(0000, 0600, 1200 and 1800 Hours)

Elevation Angle = 0°

AOI	00 00				06 00				12 00				18 00			
	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	334.0	283.0	288.4	337.2	334.0	285.8	289.9	339.3	334.0	269.1	279.0	322.2	334.0	271.1	280.2	323.2
(2) Amazon Forest (AMFOR)	429.2	328.2	337.4	423.4	425.7	326.8	335.3	420.3	427.7	327.7	336.5	422.0	419.4	323.2	333.5	414.4
(3) Bangkok, Thailand (BANGK)	429.9	326.9	336.0	426.6	429.1	326.6	335.6	424.9	427.9	325.8	335.1	423.5	425.7	325.1	334.3	421.2
(4) Washington, D.C. (DC)	344.8	295.4	293.9	348.1	338.9	293.5	291.2	342.0	337.3	293.3	290.5	340.6	335.4	291.3	290.0	340.0
(5) Alaska (NAK)	336.9	292.7	291.0	342.4	337.3	293.1	291.2	342.5	337.5	294.1	291.4	342.6	338.1	294.2	291.8	342.6
(6) Northern Australia, Tanami Desert (NAUS)	386.0	304.3	312.8	382.4	375.0	296.9	308.2	371.5	388.3	305.7	315.6	385.3	396.6	311.2	319.6	393.1
(7) Pyrenee Mountains (PYRNES)	349.2	295.5	295.9	353.6	348.1	294.7	295.6	352.4	348.5	294.7	295.7	352.8	349.2	295.4	296.1	353.5
(8) Spokane, Washington (SPOK)	374.3	307.5	310.1	375.5	371.0	306.9	308.7	372.2	364.2	304.1	305.7	368.1	365.5	304.4	306.0	370.0
(9) Tehran, Iran (TEHRAN)	320.8	275.7	280.7	322.0	318.3	272.1	279.2	319.4	313.8	266.3	275.9	314.7	320.5	276.3	281.5	323.5
(10) Xining, China (XINING)	345.0	293.3	295.8	350.2	327.5	277.4	284.6	331.7	332.1	281.7	287.5	336.6	339.2	287.9	292.0	343.9

Elevation Angle = 1°

AOI	00 00				06 00				12 00				18 00			
	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	232.9	197.5	202.7	236.8	234.0	199.6	203.5	237.8	225.9	188.4	197.8	228.4	226.0	189.9	198.4	228.9
(2) Amazon Forest (AMFOR)	285.5	220.7	229.8	281.0	283.6	220.1	228.6	279.5	284.9	220.6	229.4	280.4	281.7	217.7	227.7	276.6
(3) Bangkok, Thailand (BANGK)	288.9	219.9	228.9	285.9	287.1	219.8	228.7	284.5	287.3	219.3	228.4	283.6	286.2	218.9	228.0	282.0
(4) Washington, D.C. (DC)	238.5	205.8	204.6	241.9	234.8	205.0	203.1	237.9	233.7	205.3	202.8	237.0	232.6	203.9	202.8	237.2
(5) Alaska (NAK)	233.1	204.9	203.4	238.6	233.7	205.2	203.6	238.7	233.4	206.1	203.7	238.8	233.8	206.1	204.1	238.6
(6) Northern Australia, Tanami Desert (NAUS)	265.3	207.9	216.2	261.1	260.2	202.8	213.7	255.3	265.8	208.1	217.8	263.0	268.8	211.6	219.8	266.6
(7) Pyrenee Mountains (PYRNES)	240.7	205.8	206.3	245.6	240.3	205.1	206.1	244.9	240.4	205.1	206.2	245.1	240.7	205.5	206.4	245.4
(8) Spokane, Washington (SPOK)	255.2	211.6	214.3	257.4	253.0	211.5	213.5	254.9	248.8	209.9	211.8	253.3	249.5	210.1	211.9	254.8
(9) Tehran, Iran (TEHRAN)	227.0	194.0	198.8	228.0	225.9	191.4	198.0	226.6	223.3	187.2	196.2	223.7	226.0	194.3	199.2	228.9
(10) Xining, China (XINING)	239.4	204.4	206.9	244.9	229.5	193.9	200.6	234.1	232.0	196.7	202.2	236.9	235.8	200.7	204.7	240.8

Elevation Angle = 3°

AOI	00 00				06 00				12 00				18 00			
	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	132.6	115.5	119.4	135.6	133.0	116.7	119.7	135.9	130.1	110.4	117.5	132.3	130.0	111.2	117.7	132.4
(2) Amazon Forest (AMFOR)	154.6	125.5	132.6	150.6	153.8	125.3	131.9	150.2	154.6	125.6	132.3	150.6	153.5	123.9	131.6	149.2
(3) Bangkok, Thailand (BANGK)	157.4	125.1	132.1	154.8	156.2	125.0	132.0	154.0	156.6	124.8	131.8	153.4	156.1	124.6	131.6	152.6
(4) Washington, D.C. (DC)	133.9	120.1	119.4	136.7	132.1	119.9	118.6	134.6	131.6	120.2	118.5	134.3	131.2	119.4	118.7	134.8
(5) Alaska (NAK)	131.2	120.0	119.0	135.6	131.6	120.2	119.1	135.6	131.4	120.8	119.2	135.7	131.7	120.8	119.4	135.5
(6) Northern Australia, Tanami Desert (NAUS)	147.8	119.6	126.0	144.5	146.0	116.7	125.0	142.3	147.8	119.5	126.9	145.5	148.4	121.3	127.7	146.4
(7) Pyrenee Mountains (PYRNES)	135.1	120.1	120.6	138.9	135.0	119.6	120.6	138.6	135.0	119.6	120.6	138.7	135.0	119.9	120.7	138.7
(8) Spokane, Washington (SPOK)	141.7	122.4	124.7	143.3	140.5	122.4	124.2	141.7	138.4	121.7	123.3	141.6	138.7	121.8	123.4	142.6
(9) Tehran, Iran (TEHRAN)	130.8	114.1	117.7	131.9	130.4	112.4	117.5	131.3	129.3	110.0	116.8	130.0	129.9	114.1	117.9	132.4
(10) Xining, China (XINING)	135.2	119.3	121.4	139.6	131.1	113.4	118.5	134.9	132.1	115.0	119.2	136.0	133.6	117.2	120.3	137.5

Elevation Angle = 5°

AOI	00 00				06 00				12 00				18 00			
	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	89.4	78.9	81.9	91.6	89.7	79.7	82.1	91.8	88.0	75.5	80.8	89.7	88.0	76.0	80.9	89.8
(2) Amazon Forest (AMFOR)	102.6	85.0	90.4	99.4	102.2	85.0	89.9	99.2	102.7	85.1	90.2	99.5	102.1	84.0	89.8	98.6
(3) Bangkok, Thailand (BANGK)	104.6	84.8	90.1	102.5	103.8	84.7	90.0	101.9	104.0	84.5	89.9	101.5	103.8	84.5	89.8	101.0
(4) Washington, D.C. (DC)	89.8	82.0	81.5	91.9	88.6	81.9	81.0	90.5	88.4	82.1	80.9	90.4	88.1	81.6	81.2	90.9
(5) Alaska (NAK)	88.0	82.0	81.3	91.3	88.4	82.2	81.4	91.4	88.2	82.6	81.4	91.4	88.4	82.6	81.6	91.2
(6) Northern Australia, Tanami Desert (NAUS)	98.9	81.4	86.2	96.5	97.9	79.4	85.6	95.2	98.8	81.2	86.8	97.1	99.0	82.4	87.2	97.4
(7) Pyrenee Mountains (PYRNES)	90.7	82.0	82.5	93.4	90.6	81.7	82.4	93.3	90.6	81.7	82.5	93.3	90.6	81.8	82.5	93.3
(8) Spokane, Washington (SPOK)	94.8	83.3	85.1	95.8	94.0	83.4	84.8	94.8	92.7	83.0	84.2	94.9	92.8	83.0	84.2	95.5
(9) Tehran, Iran (TEHRAN)	88.4	78.1	80.8	89.5	88.3	76.9	80.7	89.1	87.6	75.2	80.4	88.3	87.9	78.1	81.0	89.8
(10) Xining, China (XINING)	90.9	81.5	83.1	94.1	88.5	77.5	81.4	91.4	89.0	78.6	81.8	92.0	89.9	80.0	82.4	92.8

Elevation Angle = 10°

AOI	00 00				06 00				12 00				18 00			
	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.	MRF	Hop.	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	48.0	42.8	44.6	49.2	48.1	43.3	44.6	49.3	47.3	41.0	44.1	48.4	47.3	41.3	44.1	48.4
(2) Amazon Forest (AMFOR)	54.5	45.8	49.0	52.6	54.3	45.8	48.8	52.5	54.6	45.9	48.9	52.7	54.3	45.3	48.7	52.3
(3) Bangkok, Thailand (BANGK)	55.6	45.7	48.9	54.3	55.2	45.7	48.8	54.0	55.3	45.6	48.8	53.8	55.2	45.5	48.7	53.5
(4) Washington, D.C. (DC)	48.0	44.5	44.2	49.2	47.4	44.4	44.0	48.5	47.3	44.6	43.9	48.5	47.2	44.3	44.1	48.8
(5) Alaska (NAK)	47.1	44.5	44.1	49.0	47.3	44.6	44.2	49.0	47.2	44.8	44.2	49.1	47.3	44.8	44.3	49.0
(6) Northern Australia, Tanami Desert (NAUS)	52.8	44.0	46.8	51.4	52.3	42.9	46.6	50.8	52.8	43.8	47.2	51.7	52.8	44.5	47.4	51.8
(7) Pyrenee Mountains (PYRNES)	48.5	44.4	44.8	50.1	48.5	44.3	44.8	50.0	48.4	44.3	44.8	50.0	48.4	44.4	44.8	50.0
(8) Spokane, Washington (SPOK)	50.6	45.1	46.2	51.2	50.2	45.1	46.0	50.6	49.5	44.9	45.7	50.7	49.6	44.9	45.7	51.1
(9) Tehran, Iran (TEHRAN)	47.6	42.4	44.0	48.2	47.5	41.8	44.0	48.1	47.1	40.9	43.9	47.7	47.2	42.4	44.1	48.4
(10) Xining, China (XINING)	48.7	44.2	45.1	50.6	47.5	42.0	44.3	49.2	47.8	42.6	44.5	49.5	48.2	43.4	44.8	49.8

Angle Error (degrees) for Selected Areas-of-Interest
MRF, Goad and Exponential Model for 15 February 1995
(0000, 0600, 1200 and 1800 Hours)

AOI	Elevation Angle = 0°											
	0000			0600			1200			1800		
	MRF	Goad	Exp.	MRF	Goad	Exp.	MRF	Goad	Exp.	MRF	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	0.2701	0.5756	0.2635	0.2912	0.5906	0.2709	0.2346	0.5311	0.2397	0.2362	0.5330	0.2381
(2) Amazon Forest (AMFOR)	0.4807	0.9099	0.4489	0.4786	0.9040	0.4453	0.4852	0.9029	0.4473	0.4867	0.9144	0.4500
(3) Bangkok, Thailand (BANGK)	0.5054	0.9090	0.4623	0.4467	0.8637	0.4301	0.4617	0.8850	0.4458	0.4684	0.8946	0.4537
(4) Washington, D.C. (DC)	0.2672	0.5833	0.2724	0.2660	0.5886	0.2737	0.2734	0.6193	0.2876	0.2960	0.6689	0.3100
(5) Alaska (NAK)	0.3048	0.6169	0.2833	0.3061	0.6201	0.2847	0.3072	0.6160	0.2824	0.3113	0.6187	0.2843
(6) Northern Australia, Tanami Desert (NAUS)	0.4198	0.8229	0.3834	0.3078	0.7295	0.3106	0.3496	0.7693	0.3343	0.3978	0.8060	0.3655
(7) Pyrenee Mountains (PYRNES)	0.3096	0.6189	0.2914	0.3089	0.6214	0.2912	0.3107	0.6193	0.2912	0.3163	0.6260	0.2936
(8) Spokane, Washington (SPOK)	0.2731	0.5845	0.2762	0.2875	0.6030	0.2861	0.2768	0.5945	0.2755	0.2788	0.6130	0.2749
(9) Tehran, Iran (TEHRAN)	0.3372	0.6933	0.3157	0.3385	0.6969	0.3198	0.3309	0.7020	0.3239	0.3324	0.6989	0.3230
(10) Xining, China (XINING)	0.3003	0.6310	0.2956	0.2857	0.6065	0.2739	0.2842	0.6053	0.2734	0.3007	0.6339	0.2901
	Elevation Angle = 1°											
	0000			0600			1200			1800		
	MRF	Goad	Exp.	MRF	Goad	Exp.	MRF	Goad	Exp.	MRF	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	0.2376	0.4225	0.2326	0.2528	0.4319	0.2386	0.2141	0.3939	0.2128	0.2122	0.3952	0.2114
(2) Amazon Forest (AMFOR)	0.3939	0.6179	0.3813	0.3918	0.6144	0.3784	0.3944	0.6138	0.3795	0.3965	0.6205	0.3822
(3) Bangkok, Thailand (BANGK)	0.4055	0.6173	0.3914	0.3723	0.5904	0.3666	0.3853	0.6029	0.3795	0.3878	0.6087	0.3845
(4) Washington, D.C. (DC)	0.2402	0.4301	0.2396	0.2398	0.4336	0.2408	0.2464	0.4511	0.2522	0.2648	0.4783	0.2705
(5) Alaska (NAK)	0.2623	0.4483	0.2494	0.2638	0.4501	0.2506	0.2635	0.4478	0.2487	0.2662	0.4494	0.2502
(6) Northern Australia, Tanami Desert (NAUS)	0.3476	0.5658	0.3328	0.2773	0.5095	0.2791	0.2990	0.5336	0.2952	0.3312	0.5556	0.3206
(7) Pyrenee Mountains (PYRNES)	0.2665	0.4498	0.2549	0.2662	0.4511	0.2547	0.2670	0.4498	0.2547	0.2704	0.4537	0.2566
(8) Spokane, Washington (SPOK)	0.2430	0.4317	0.2423	0.2532	0.4432	0.2501	0.2460	0.4368	0.2432	0.2514	0.4458	0.2478
(9) Tehran, Iran (TEHRAN)	0.2875	0.4912	0.2754	0.2895	0.4934	0.2786	0.2875	0.4959	0.2823	0.2885	0.4946	0.2812
(10) Xining, China (XINING)	0.2631	0.4575	0.2589	0.2486	0.4402	0.2412	0.2476	0.4399	0.2406	0.2614	0.4578	0.2543
	Elevation Angle = 3°											
	0000			0600			1200			1800		
	MRF	Goad	Exp.	MRF	Goad	Exp.	MRF	Goad	Exp.	MRF	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	0.1506	0.2530	0.1481	0.1573	0.2577	0.1516	0.1393	0.2380	0.1368	0.1378	0.2387	0.1361
(2) Amazon Forest (AMFOR)	0.2322	0.3475	0.2327	0.2310	0.3458	0.2311	0.2316	0.3456	0.2315	0.2329	0.3488	0.2332
(3) Bangkok, Thailand (BANGK)	0.2355	0.3471	0.2376	0.2220	0.3339	0.2245	0.2286	0.3400	0.2316	0.2298	0.3429	0.2339
(4) Washington, D.C. (DC)	0.1537	0.2579	0.1516	0.1540	0.2597	0.1524	0.1588	0.2680	0.1592	0.1691	0.2805	0.1700
(5) Alaska (NAK)	0.1639	0.2659	0.1586	0.1648	0.2667	0.1593	0.1642	0.2656	0.1582	0.1653	0.2664	0.1590
(6) Northern Australia, Tanami Desert (NAUS)	0.2085	0.3217	0.2072	0.1766	0.2936	0.1781	0.1862	0.3057	0.1869	0.2013	0.3166	0.2011
(7) Pyrenee Mountains (PYRNES)	0.1660	0.2668	0.1610	0.1659	0.2674	0.1609	0.1661	0.2668	0.1609	0.1676	0.2687	0.1621
(8) Spokane, Washington (SPOK)	0.1558	0.2587	0.1535	0.1608	0.2645	0.1579	0.1575	0.2609	0.1546	0.1608	0.2645	0.1581
(9) Tehran, Iran (TEHRAN)	0.1775	0.2861	0.1734	0.1789	0.2872	0.1751	0.1797	0.2882	0.1775	0.1796	0.2878	0.1765
(10) Xining, China (XINING)	0.1649	0.2710	0.1624	0.1573	0.2613	0.1536	0.1567	0.2613	0.1530	0.1640	0.2705	0.1605
	Elevation Angle = 5°											
	0000			0600			1200			1800		
	MRF	Goad	Exp.	MRF	Goad	Exp.	MRF	Goad	Exp.	MRF	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	0.1042	0.1747	0.1026	0.1082	0.1778	0.1050	0.0969	0.1650	0.0951	0.0961	0.1655	0.0946
(2) Amazon Forest (AMFOR)	0.1566	0.2349	0.1584	0.1558	0.2338	0.1573	0.1561	0.2337	0.1576	0.1569	0.2358	0.1587
(3) Bangkok, Thailand (BANGK)	0.1582	0.2347	0.1613	0.1501	0.2262	0.1529	0.1542	0.2301	0.1575	0.1551	0.2320	0.1590
(4) Washington, D.C. (DC)	0.1065	0.1780	0.1048	0.1068	0.1792	0.1054	0.1103	0.1844	0.1099	0.1170	0.1923	0.1172
(5) Alaska (NAK)	0.1128	0.1828	0.1096	0.1134	0.1834	0.1100	0.1129	0.1827	0.1093	0.1136	0.1832	0.1098
(6) Northern Australia, Tanami Desert (NAUS)	0.1413	0.2184	0.1419	0.1217	0.2004	0.1228	0.1277	0.2081	0.1287	0.1371	0.2151	0.1379
(7) Pyrenee Mountains (PYRNES)	0.1142	0.1835	0.1111	0.1141	0.1839	0.1110	0.1142	0.1835	0.1110	0.1151	0.1847	0.1118
(8) Spokane, Washington (SPOK)	0.1079	0.1784	0.1060	0.1112	0.1821	0.1089	0.1090	0.1797	0.1067	0.1111	0.1819	0.1091
(9) Tehran, Iran (TEHRAN)	0.1217	0.1958	0.1195	0.1227	0.1965	0.1206	0.1235	0.1971	0.1221	0.1233	0.1969	0.1215
(10) Xining, China (XINING)	0.1136	0.1864	0.1120	0.1087	0.1799	0.1063	0.1083	0.1800	0.1058	0.1131	0.1859	0.1108
	Elevation Angle = 10°											
	0000			0600			1200			1800		
	MRF	Goad	Exp.	MRF	Goad	Exp.	MRF	Goad	Exp.	MRF	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	0.0564	0.0948	0.0555	0.0583	0.0964	0.0568	0.0527	0.0899	0.0516	0.0522	0.0901	0.0514
(2) Amazon Forest (AMFOR)	0.0832	0.1257	0.0846	0.0828	0.1251	0.0841	0.0830	0.1250	0.0842	0.0834	0.1261	0.0848
(3) Bangkok, Thailand (BANGK)	0.0839	0.1255	0.0861	0.0799	0.1212	0.0818	0.0820	0.1232	0.0842	0.0825	0.1242	0.0849
(4) Washington, D.C. (DC)	0.0577	0.0965	0.0567	0.0579	0.0971	0.0570	0.0598	0.0998	0.0594	0.0632	0.1038	0.0632
(5) Alaska (NAK)	0.0608	0.0989	0.0592	0.0611	0.0992	0.0594	0.0609	0.0988	0.0590	0.0612	0.0991	0.0593
(6) Northern Australia, Tanami Desert (NAUS)	0.0754	0.1172	0.0761	0.0656	0.1079	0.0662	0.0687	0.1119	0.0693	0.0734	0.1155	0.0741
(7) Pyrenee Mountains (PYRNES)	0.0615	0.0993	0.0600	0.0615	0.0995	0.0599	0.0616	0.0993	0.0599	0.0620	0.0999	0.0604
(8) Spokane, Washington (SPOK)	0.0584	0.0966	0.0572	0.0601	0.0985	0.0588	0.0590	0.0972	0.0576	0.0601	0.0983	0.0589
(9) Tehran, Iran (TEHRAN)	0.0655	0.1056	0.0644	0.0660	0.1059	0.0650	0.0664	0.1062	0.0658	0.0663	0.1061	0.0654
(10) Xining, China (XINING)	0.0613	0.1008	0.0604	0.0588	0.0974	0.0575	0.0586	0.0975	0.0572	0.0611	0.1005	0.0598

Angle Error (degrees) for Selected Areas-of-Interest

MRF, Goad and Exponential Model for 15 May 1995
(0000, 0600, 1200 and 1800 Hours)

	Elevation Angle = 0°											
	0000			0600			1200			1800		
AOI	MRF	Goad	Exp.	MRF	Goad	Exp.	MRF	Goad	Exp.	MRF	Goad	Exp
(1) Ahaggar, Algeria (AHAGR)	0.2334	0.5020	0.2204	0.2478	0.5179	0.2294	0.2001	0.4746	0.2044	0.1940	0.4651	0.2000
(2) Amazon Forest (AMFOR)	0.5059	0.9436	0.4753	0.4913	0.9312	0.4595	0.4976	0.9261	0.4545	0.5010	0.9364	0.4601
(3) Bangkok, Thailand (BANGK)	0.4953	0.9389	0.4540	0.5355	0.9578	0.4704	0.4995	0.9270	0.4495	0.5437	0.9780	0.4955
(4) Washington, D.C. (DC)	0.4817	0.8483	0.4175	0.4650	0.8218	0.4005	0.4458	0.7983	0.3823	0.4073	0.7666	0.3647
(5) Alaska (NAK)	0.3124	0.6388	0.2946	0.3137	0.6410	0.2960	0.3128	0.6379	0.2957	0.3116	0.6397	0.2962
(6) Northern Australia, Tanami Desert (NAUS)	0.3042	0.6818	0.3207	0.2765	0.6781	0.3051	0.3046	0.7115	0.3289	0.3363	0.7359	0.3461
(7) Pyrenee Mountains (PYRNES)	0.3358	0.6776	0.3082	0.3246	0.6776	0.3008	0.3187	0.6687	0.2962	0.3299	0.6724	0.3043
(8) Spokane, Washington (SPOK)	0.3315	0.7008	0.3160	0.3815	0.7822	0.3597	0.3336	0.7111	0.3208	0.3634	0.7458	0.3441
(9) Tehran, Iran (TEHRAN)	0.3500	0.7377	0.3400	0.3226	0.7054	0.3233	0.2980	0.6828	0.3058	0.3370	0.7317	0.3413
(10) Xining, China (XINING)	0.3243	0.6746	0.3080	0.2506	0.5606	0.2367	0.2797	0.6238	0.2636	0.3457	0.7201	0.3258
	Elevation Angle = 1°											
	0000			0600			1200			1800		
	MRF	Goad	Exp.	MRF	Goad	Exp.	MRF	Goad	Exp.	MRF	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	0.2024	0.3763	0.1968	0.2129	0.3867	0.2043	0.1804	0.3573	0.1836	0.1756	0.3517	0.1801
(2) Amazon Forest (AMFOR)	0.4108	0.6379	0.4015	0.4010	0.6305	0.3899	0.4024	0.6276	0.3858	0.4069	0.6336	0.3912
(3) Bangkok, Thailand (BANGK)	0.4067	0.6350	0.3877	0.4277	0.6462	0.4002	0.4077	0.6278	0.3851	0.4359	0.6583	0.4179
(4) Washington, D.C. (DC)	0.3853	0.5813	0.3573	0.3719	0.5658	0.3438	0.3560	0.5520	0.3293	0.3365	0.5331	0.3153
(5) Alaska (NAK)	0.2695	0.4608	0.2580	0.2704	0.4621	0.2590	0.2695	0.4606	0.2587	0.2691	0.4616	0.2591
(6) Northern Australia, Tanami Desert (NAUS)	0.2696	0.4831	0.2796	0.2527	0.4801	0.2674	0.2722	0.5008	0.2860	0.2934	0.5155	0.2998
(7) Pyrenee Mountains (PYRNES)	0.2851	0.4818	0.2697	0.2776	0.4816	0.2637	0.2730	0.4764	0.2599	0.2813	0.4786	0.2666
(8) Spokane, Washington (SPOK)	0.2901	0.4939	0.2781	0.3281	0.5422	0.3146	0.2927	0.5005	0.2832	0.3147	0.5208	0.3016
(9) Tehran, Iran (TEHRAN)	0.3015	0.5163	0.2958	0.2836	0.4964	0.2826	0.2648	0.4823	0.2697	0.2950	0.5121	0.2968
(10) Xining, China (XINING)	0.2808	0.4795	0.2692	0.2230	0.4091	0.2152	0.2492	0.4470	0.2398	0.2987	0.5052	0.2862
	Elevation Angle = 3°											
	0000			0600			1200			1800		
	MRF	Goad	Exp.	MRF	Goad	Exp.	MRF	Goad	Exp.	MRF	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	0.1302	0.2292	0.1280	0.1355	0.2346	0.1324	0.1201	0.2188	0.1203	0.1174	0.2160	0.1184
(2) Amazon Forest (AMFOR)	0.2411	0.3573	0.2435	0.2366	0.3537	0.2376	0.2362	0.3523	0.2354	0.2389	0.3551	0.2387
(3) Bangkok, Thailand (BANGK)	0.2395	0.3558	0.2374	0.2470	0.3613	0.2439	0.2387	0.3522	0.2361	0.2521	0.3673	0.2526
(4) Washington, D.C. (DC)	0.2239	0.3296	0.2197	0.2167	0.3220	0.2121	0.2089	0.3154	0.2042	0.2009	0.3060	0.1964
(5) Alaska (NAK)	0.1683	0.2719	0.1632	0.1687	0.2726	0.1637	0.1682	0.2720	0.1635	0.1682	0.2724	0.1637
(6) Northern Australia, Tanami Desert (NAUS)	0.1724	0.2816	0.1761	0.1652	0.2798	0.1696	0.1747	0.2903	0.1796	0.1845	0.2977	0.1874
(7) Pyrenee Mountains (PYRNES)	0.1758	0.2814	0.1705	0.1722	0.2813	0.1672	0.1697	0.2787	0.1650	0.1739	0.2798	0.1688
(8) Spokane, Washington (SPOK)	0.1806	0.2867	0.1762	0.2006	0.3103	0.1971	0.1825	0.2900	0.1793	0.1933	0.2999	0.1895
(9) Tehran, Iran (TEHRAN)	0.1873	0.2979	0.1857	0.1789	0.2878	0.1784	0.1700	0.2806	0.1716	0.1851	0.2956	0.1863
(10) Xining, China (XINING)	0.1745	0.2801	0.1701	0.1436	0.2443	0.1402	0.1586	0.2631	0.1550	0.1847	0.2922	0.1809
	Elevation Angle = 5°											
	0000			0600			1200			1800		
	MRF	Goad	Exp.	MRF	Goad	Exp.	MRF	Goad	Exp.	MRF	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	0.0909	0.1593	0.0893	0.0942	0.1628	0.0922	0.0845	0.1525	0.0841	0.0828	0.1507	0.0827
(2) Amazon Forest (AMFOR)	0.1624	0.2412	0.1654	0.1597	0.2389	0.1617	0.1592	0.2380	0.1602	0.1610	0.2398	0.1624
(3) Bangkok, Thailand (BANGK)	0.1614	0.2402	0.1617	0.1657	0.2437	0.1658	0.1605	0.2379	0.1608	0.1690	0.2476	0.1713
(4) Washington, D.C. (DC)	0.1506	0.2234	0.1499	0.1460	0.2186	0.1449	0.1411	0.2144	0.1398	0.1362	0.2084	0.1347
(5) Alaska (NAK)	0.1158	0.1867	0.1127	0.1161	0.1872	0.1130	0.1158	0.1868	0.1128	0.1158	0.1871	0.1130
(6) Northern Australia, Tanami Desert (NAUS)	0.1192	0.1929	0.1213	0.1148	0.1916	0.1171	0.1209	0.1984	0.1236	0.1269	0.2031	0.1288
(7) Pyrenee Mountains (PYRNES)	0.1205	0.1927	0.1176	0.1182	0.1926	0.1154	0.1167	0.1910	0.1139	0.1193	0.1917	0.1165
(8) Spokane, Washington (SPOK)	0.1238	0.1960	0.1215	0.1367	0.2111	0.1352	0.1251	0.1981	0.1235	0.1319	0.2044	0.1301
(9) Tehran, Iran (TEHRAN)	0.1284	0.2032	0.1277	0.1231	0.1968	0.1229	0.1177	0.1921	0.1184	0.1272	0.2017	0.1281
(10) Xining, China (XINING)	0.1198	0.1919	0.1174	0.0997	0.1688	0.0975	0.1096	0.1808	0.1075	0.1263	0.1995	0.1246
	Elevation Angle = 10°											
	0000			0600			1200			1800		
	MRF	Goad	Exp.	MRF	Goad	Exp.	MRF	Goad	Exp.	MRF	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	0.0495	0.0869	0.0486	0.0512	0.0887	0.0501	0.0463	0.0834	0.0458	0.0454	0.0825	0.0451
(2) Amazon Forest (AMFOR)	0.0863	0.1289	0.0883	0.0849	0.1277	0.0864	0.0846	0.1273	0.0856	0.0855	0.1282	0.0867
(3) Bangkok, Thailand (BANGK)	0.0858	0.1284	0.0864	0.0878	0.1302	0.0885	0.0852	0.1272	0.0859	0.0896	0.1322	0.0913
(4) Washington, D.C. (DC)	0.0800	0.1197	0.0802	0.0776	0.1173	0.0777	0.0752	0.1151	0.0750	0.0727	0.1120	0.0723
(5) Alaska (NAK)	0.0625	0.1009	0.0608	0.0626	0.1011	0.0610	0.0624	0.1009	0.0609	0.0625	0.1011	0.0610
(6) Northern Australia, Tanami Desert (NAUS)	0.0644	0.1041	0.0654	0.0622	0.1035	0.0632	0.0654	0.1070	0.0666	0.0684	0.1094	0.0693
(7) Pyrenee Mountains (PYRNES)	0.0648	0.1040	0.0635	0.0636	0.1039	0.0623	0.0628	0.1031	0.0615	0.0642	0.1035	0.0629
(8) Spokane, Washington (SPOK)	0.0665	0.1057	0.0655	0.0732	0.1134	0.0727	0.0672	0.1067	0.0665	0.0706	0.1100	0.0700
(9) Tehran, Iran (TEHRAN)	0.0690	0.1094	0.0688	0.0663	0.1061	0.0662	0.0636	0.1037	0.0639	0.0684	0.1086	0.0689
(10) Xining, China (XINING)	0.0645	0.1036	0.0634	0.0541	0.0917	0.0529	0.0593	0.0979	0.0582	0.0678	0.1074	0.0672

Angle Error (degrees) for Selected Areas-of-Interest
MRF, Goad and Exponential Model for 15 August 1995
(0000, 0600, 1200 and 1800 Hours)

AOI	0000			0600			1200			1800		
	MRF	Goad	Exp.	MRF	Goad	Exp.	MRF	Goad	Exp.	MRF	Goad	Exp.
Elevation Angle = 0°												
(1) Ahaggar, Algeria (AHAGR)	0.2542	0.5535	0.2437	0.2851	0.5818	0.2597	0.2288	0.5278	0.2259	0.1994	0.4878	0.2095
(2) Amazon Forest (AMFOR)	0.4824	0.8894	0.4265	0.4875	0.8853	0.4275	0.4904	0.8862	0.4313	0.5383	1.0088	0.5159
(3) Bangkok, Thailand (BANGK)	0.4914	0.9510	0.4533	0.4900	0.9438	0.4519	0.4840	0.9362	0.4431	0.5214	0.9648	0.4711
(4) Washington, D.C. (DC)	0.5401	0.9405	0.4825	0.5402	0.9411	0.4885	0.5255	0.9307	0.4829	0.5140	0.9090	0.4701
(5) Alaska (NAK)	0.3457	0.6860	0.3182	0.3450	0.6926	0.3217	0.3462	0.6876	0.3202	0.3468	0.6930	0.3235
(6) Northern Australia, Tanami Desert (NAUS)	0.2886	0.5957	0.2751	0.2340	0.5401	0.2459	0.2701	0.5779	0.2647	0.2930	0.6033	0.2790
(7) Pyrenee Mountains (PYRNES)	0.3706	0.7421	0.3414	0.4329	0.8780	0.4293	0.3518	0.7341	0.3308	0.3662	0.7391	0.3376
(8) Spokane, Washington (SPOK)	0.3093	0.6775	0.3047	0.3368	0.7154	0.3269	0.3385	0.7140	0.3259	0.3492	0.7386	0.3367
(9) Tehran, Iran (TEHRAN)	0.3134	0.6876	0.3146	0.2581	0.6018	0.2636	0.1440	0.4327	0.1782	0.1985	0.5122	0.2199
(10) Xining, China (XINING)	0.4893	0.9555	0.4580	0.5081	0.9913	0.4905	0.4699	0.9326	0.4664	0.4417	0.8648	0.4226
Elevation Angle = 1°												
	0000			0600			1200			1800		
	MRF	Goad	Exp.	MRF	Goad	Exp.	MRF	Goad	Exp.	MRF	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	0.2203	0.4058	0.2168	0.2401	0.4233	0.2300	0.2005	0.3889	0.2019	0.1809	0.3647	0.1884
(2) Amazon Forest (AMFOR)	0.3895	0.6056	0.3651	0.3913	0.6032	0.3657	0.3923	0.6038	0.3678	0.4418	0.6770	0.4325
(3) Bangkok, Thailand (BANGK)	0.4009	0.6422	0.3874	0.3995	0.6379	0.3863	0.3937	0.6334	0.3800	0.4157	0.6505	0.4001
(4) Washington, D.C. (DC)	0.4284	0.6363	0.4065	0.4280	0.6366	0.4102	0.4202	0.6304	0.4056	0.4132	0.6176	0.3961
(5) Alaska (NAK)	0.2912	0.4874	0.2776	0.2921	0.4912	0.2804	0.2921	0.4883	0.2790	0.2942	0.4916	0.2816
(6) Northern Australia, Tanami Desert (NAUS)	0.2530	0.4342	0.2420	0.2163	0.3989	0.2178	0.2401	0.4231	0.2334	0.2558	0.4387	0.2450
(7) Pyrenee Mountains (PYRNES)	0.3109	0.5190	0.2964	0.3674	0.5991	0.3661	0.2993	0.5142	0.2880	0.3081	0.5172	0.2934
(8) Spokane, Washington (SPOK)	0.2716	0.4802	0.2696	0.2938	0.5028	0.2890	0.2949	0.5022	0.2880	0.3071	0.5162	0.2994
(9) Tehran, Iran (TEHRAN)	0.2773	0.4852	0.2770	0.2330	0.4329	0.2368	0.1428	0.3300	0.1673	0.1844	0.3795	0.1992
(10) Xining, China (XINING)	0.4051	0.6449	0.3901	0.4219	0.6663	0.4163	0.3936	0.6314	0.3958	0.3707	0.5913	0.3606
Elevation Angle = 3°												
	0000			0600			1200			1800		
	MRF	Goad	Exp.	MRF	Goad	Exp.	MRF	Goad	Exp.	MRF	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	0.1414	0.2432	0.1403	0.1506	0.2521	0.1480	0.1313	0.2342	0.1316	0.1216	0.2222	0.1235
(2) Amazon Forest (AMFOR)	0.2281	0.3414	0.2246	0.2285	0.3402	0.2248	0.2286	0.3406	0.2256	0.2585	0.3766	0.2603
(3) Bangkok, Thailand (BANGK)	0.2381	0.3593	0.2376	0.2371	0.3572	0.2369	0.2341	0.3550	0.2337	0.2436	0.3635	0.2439
(4) Washington, D.C. (DC)	0.2466	0.3566	0.2461	0.2464	0.3568	0.2475	0.2430	0.3538	0.2448	0.2392	0.3474	0.2399
(5) Alaska (NAK)	0.1790	0.2844	0.1751	0.1801	0.2862	0.1767	0.1795	0.2849	0.1757	0.1809	0.2865	0.1771
(6) Northern Australia, Tanami Desert (NAUS)	0.1580	0.2586	0.1537	0.1414	0.2403	0.1401	0.1521	0.2529	0.1490	0.1594	0.2608	0.1556
(7) Pyrenee Mountains (PYRNES)	0.1894	0.2993	0.1860	0.2223	0.3383	0.2247	0.1842	0.2969	0.1812	0.1880	0.2984	0.1843
(8) Spokane, Washington (SPOK)	0.1724	0.2799	0.1716	0.1838	0.2911	0.1827	0.1839	0.2909	0.1822	0.1908	0.2974	0.1889
(9) Tehran, Iran (TEHRAN)	0.1750	0.2820	0.1759	0.1513	0.2558	0.1530	0.1030	0.2042	0.1115	0.1254	0.2295	0.1305
(10) Xining, China (XINING)	0.2411	0.3607	0.2389	0.2507	0.3712	0.2529	0.2361	0.3541	0.2410	0.2223	0.3345	0.2216
Elevation Angle = 5°												
	0000			0600			1200			1800		
	MRF	Goad	Exp.	MRF	Goad	Exp.	MRF	Goad	Exp.	MRF	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	0.0983	0.1682	0.0976	0.1041	0.1739	0.1027	0.0920	0.1624	0.0917	0.0857	0.1547	0.0863
(2) Amazon Forest (AMFOR)	0.1537	0.2310	0.1533	0.1539	0.2303	0.1534	0.1539	0.2305	0.1538	0.1737	0.2536	0.1764
(3) Bangkok, Thailand (BANGK)	0.1610	0.2425	0.1619	0.1603	0.2411	0.1614	0.1584	0.2397	0.1593	0.1642	0.2451	0.1659
(4) Washington, D.C. (DC)	0.1653	0.2408	0.1671	0.1652	0.2409	0.1679	0.1631	0.2390	0.1661	0.1606	0.2349	0.1630
(5) Alaska (NAK)	0.1227	0.1947	0.1207	0.1235	0.1958	0.1218	0.1231	0.1950	0.1211	0.1240	0.1960	0.1220
(6) Northern Australia, Tanami Desert (NAUS)	0.1087	0.1783	0.1064	0.0984	0.1665	0.0973	0.1050	0.1746	0.1033	0.1096	0.1797	0.1077
(7) Pyrenee Mountains (PYRNES)	0.1294	0.2042	0.1280	0.1509	0.2290	0.1533	0.1261	0.2026	0.1248	0.1284	0.2036	0.1268
(8) Spokane, Washington (SPOK)	0.1190	0.1917	0.1185	0.1261	0.1988	0.1258	0.1262	0.1986	0.1254	0.1305	0.2028	0.1298
(9) Tehran, Iran (TEHRAN)	0.1204	0.1930	0.1213	0.1051	0.1761	0.1062	0.0741	0.1430	0.0782	0.0887	0.1593	0.0911
(10) Xining, China (XINING)	0.1631	0.2434	0.1629	0.1693	0.2501	0.1718	0.1599	0.2391	0.1639	0.1506	0.2267	0.1514
Elevation Angle = 10°												
	0000			0600			1200			1800		
	MRF	Goad	Exp.	MRF	Goad	Exp.	MRF	Goad	Exp.	MRF	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	0.0534	0.0914	0.0530	0.0563	0.0944	0.0557	0.0502	0.0885	0.0499	0.0470	0.0845	0.0470
(2) Amazon Forest (AMFOR)	0.0817	0.1237	0.0821	0.0818	0.1233	0.0821	0.0818	0.1234	0.0823	0.0921	0.1353	0.0940
(3) Bangkok, Thailand (BANGK)	0.0858	0.1295	0.0866	0.0854	0.1289	0.0863	0.0844	0.1281	0.0853	0.0873	0.1309	0.0886
(4) Washington, D.C. (DC)	0.0876	0.1287	0.0891	0.0876	0.1287	0.0895	0.0865	0.1277	0.0886	0.0852	0.1257	0.0870
(5) Alaska (NAK)	0.0660	0.1050	0.0651	0.0665	0.1056	0.0657	0.0662	0.1052	0.0653	0.0667	0.1057	0.0658
(6) Northern Australia, Tanami Desert (NAUS)	0.0586	0.0966	0.0576	0.0534	0.0906	0.0528	0.0568	0.0947	0.0559	0.0591	0.0973	0.0583
(7) Pyrenee Mountains (PYRNES)	0.0694	0.1099	0.0689	0.0806	0.1227	0.0820	0.0678	0.1091	0.0673	0.0689	0.1096	0.0683
(8) Spokane, Washington (SPOK)	0.0643	0.1034	0.0640	0.0679	0.1070	0.0678	0.0679	0.1070	0.0676	0.0701	0.1091	0.0699
(9) Tehran, Iran (TEHRAN)	0.0649	0.1041	0.0655	0.0570	0.0955	0.0575	0.0412	0.0785	0.0427	0.0487	0.0868	0.0496
(10) Xining, China (XINING)	0.0869	0.1300	0.0871	0.0901	0.1334	0.0917	0.0852	0.1278	0.0875	0.0804	0.1214	0.0811

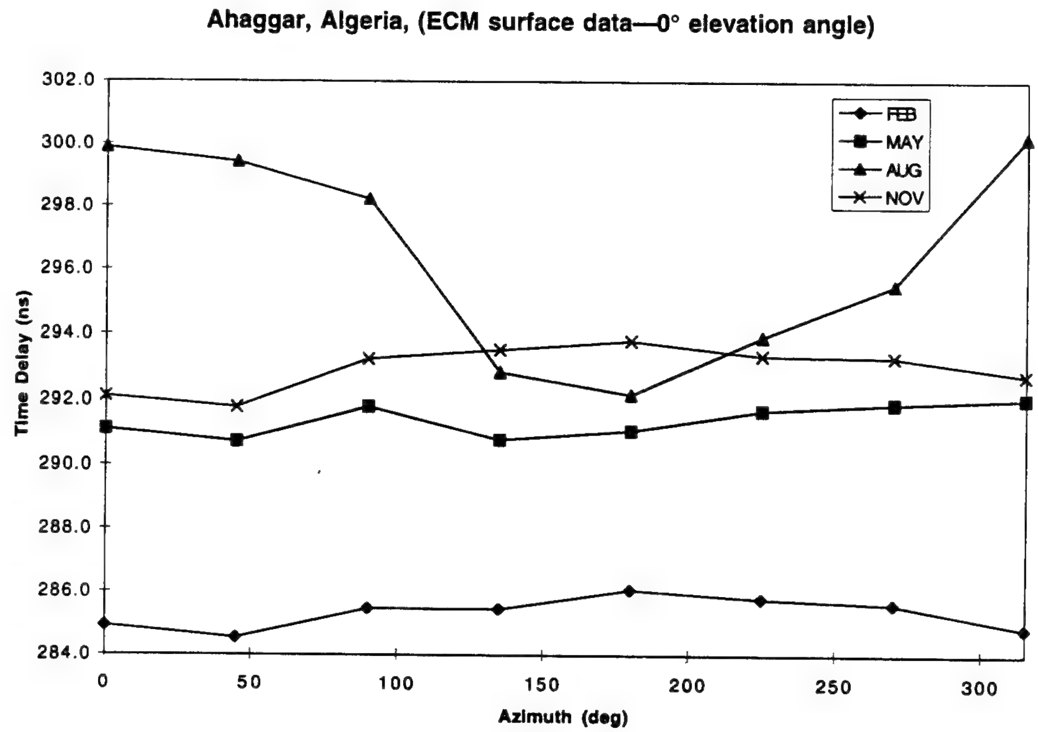
Angle Error (degrees) for Selected Areas-of-Interest
MRF, Goad and Exponential Model for 15 November 1995
(0000, 0600, 1200 and 1800 Hours)

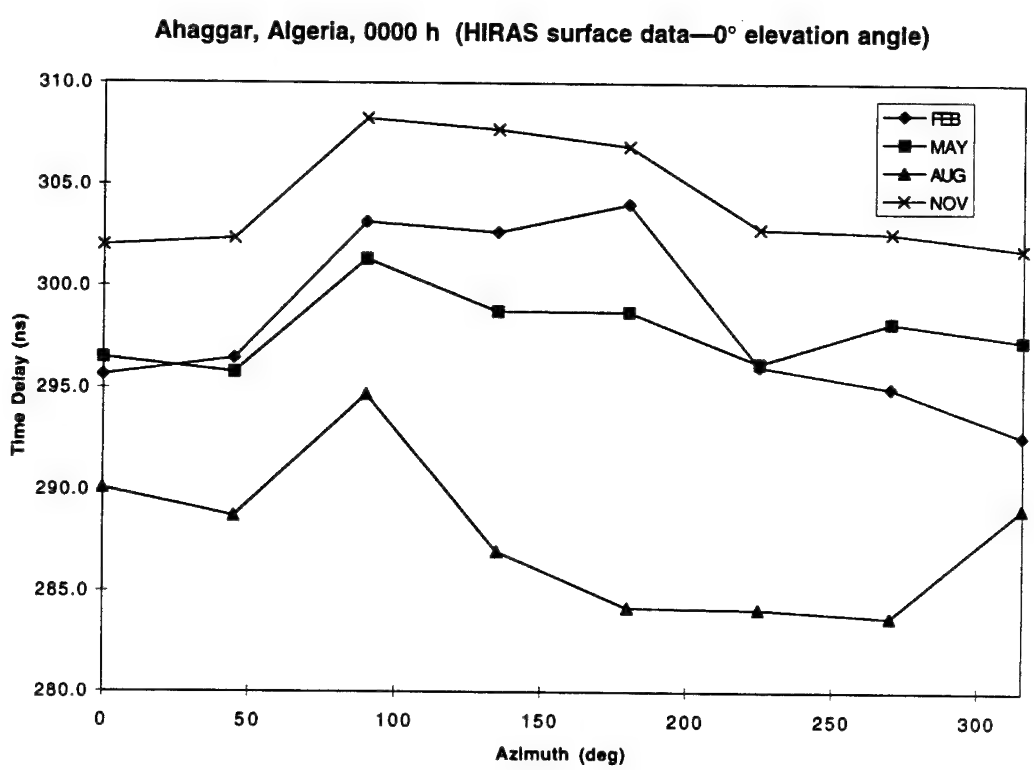
AOI	Elevation Angle = 0°											
	0000			0600			1200			1800		
	MRF	Goad	Exp.	MRF	Goad	Exp.	MRF	Goad	Exp.	MRF	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	0.2764	0.5816	0.2618	0.2830	0.5878	0.2672	0.2277	0.5261	0.2330	0.2409	0.5322	0.2356
(2) Amazon Forest (AMFOR)	0.4540	0.9021	0.4422	0.4473	0.8902	0.4350	0.4498	0.8950	0.4386	0.4200	0.8763	0.4225
(3) Bangkok, Thailand (BANGK)	0.4244	0.8960	0.4217	0.4380	0.8936	0.4221	0.4255	0.8911	0.4205	0.4208	0.8849	0.4193
(4) Washington, D.C. (DC)	0.2908	0.6344	0.2857	0.2825	0.6161	0.2796	0.2830	0.6070	0.2791	0.2829	0.5979	0.2760
(5) Alaska (NAK)	0.2881	0.6015	0.2797	0.2839	0.5996	0.2808	0.2920	0.5989	0.2810	0.2930	0.5995	0.2831
(6) Northern Australia, Tanami Desert (NAUS)	0.3370	0.7466	0.3497	0.3005	0.7207	0.3250	0.3500	0.7653	0.3505	0.3825	0.7932	0.3700
(7) Pyrenee Mountains (PYRNES)	0.3090	0.6329	0.2945	0.3030	0.6336	0.2917	0.3055	0.6340	0.2930	0.3086	0.6362	0.2953
(8) Spokane, Washington (SPOK)	0.3530	0.7275	0.3379	0.3499	0.7189	0.3375	0.3418	0.7006	0.3240	0.3449	0.7048	0.3232
(9) Tehran, Iran (TEHRAN)	0.2314	0.5225	0.2368	0.2207	0.5144	0.2316	0.2101	0.5007	0.2237	0.2403	0.5264	0.2387
(10) Xining, China (XINING)	0.2934	0.6193	0.2808	0.2590	0.5606	0.2474	0.2698	0.5767	0.2571	0.2841	0.6027	0.2723
	Elevation Angle = 1°											
	0000			0600			1200			1800		
	MRF	Goad	Exp.	MRF	Goad	Exp.	MRF	Goad	Exp.	MRF	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	0.2396	0.4249	0.2312	0.2446	0.4293	0.2355	0.2067	0.3902	0.2073	0.2127	0.3942	0.2094
(2) Amazon Forest (AMFOR)	0.3813	0.6132	0.3768	0.3758	0.6061	0.3711	0.3768	0.6091	0.3732	0.3601	0.5978	0.3618
(3) Bangkok, Thailand (BANGK)	0.3638	0.6094	0.3629	0.3688	0.6080	0.3629	0.3631	0.6064	0.3623	0.3598	0.6028	0.3606
(4) Washington, D.C. (DC)	0.2595	0.4571	0.2549	0.2531	0.4468	0.2498	0.2511	0.4420	0.2472	0.2496	0.4365	0.2430
(5) Alaska (NAK)	0.2535	0.4390	0.2457	0.2518	0.4381	0.2462	0.2548	0.4382	0.2464	0.2557	0.4386	0.2479
(6) Northern Australia, Tanami Desert (NAUS)	0.2954	0.5210	0.3038	0.2728	0.5048	0.2863	0.3031	0.5317	0.3055	0.3250	0.5484	0.3213
(7) Pyrenee Mountains (PYRNES)	0.2680	0.4566	0.2579	0.2645	0.4566	0.2558	0.2662	0.4569	0.2568	0.2683	0.4583	0.2586
(8) Spokane, Washington (SPOK)	0.3019	0.5112	0.2932	0.3010	0.5063	0.2927	0.2957	0.4956	0.2820	0.2973	0.4979	0.2817
(9) Tehran, Iran (TEHRAN)	0.2069	0.3910	0.2103	0.2000	0.3852	0.2060	0.1922	0.3756	0.1993	0.2141	0.3932	0.2120
(10) Xining, China (XINING)	0.2566	0.4488	0.2471	0.2262	0.4117	0.2194	0.2355	0.4219	0.2274	0.2487	0.4379	0.2398
	Elevation Angle = 3°											
	0000			0600			1200			1800		
	MRF	Goad	Exp.	MRF	Goad	Exp.	MRF	Goad	Exp.	MRF	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	0.1513	0.2536	0.1479	0.1537	0.2561	0.1502	0.1355	0.2359	0.1341	0.1373	0.2380	0.1352
(2) Amazon Forest (AMFOR)	0.2286	0.3452	0.2306	0.2257	0.3417	0.2275	0.2262	0.3433	0.2284	0.2195	0.3376	0.2227
(3) Bangkok, Thailand (BANGK)	0.2226	0.3432	0.2241	0.2234	0.3425	0.2241	0.2218	0.3417	0.2239	0.2201	0.3400	0.2227
(4) Washington, D.C. (DC)	0.1653	0.2696	0.1625	0.1617	0.2647	0.1593	0.1600	0.2626	0.1575	0.1585	0.2599	0.1547
(5) Alaska (NAK)	0.1604	0.2613	0.1560	0.1599	0.2610	0.1561	0.1604	0.2612	0.1561	0.1607	0.2615	0.1568
(6) Northern Australia, Tanami Desert (NAUS)	0.1866	0.3000	0.1904	0.1765	0.2916	0.1814	0.1898	0.3051	0.1919	0.1999	0.3133	0.2007
(7) Pyrenee Mountains (PYRNES)	0.1676	0.2696	0.1632	0.1662	0.2695	0.1622	0.1670	0.2696	0.1627	0.1679	0.2703	0.1637
(8) Spokane, Washington (SPOK)	0.1860	0.2958	0.1835	0.1854	0.2935	0.1831	0.1820	0.2883	0.1772	0.1829	0.2893	0.1774
(9) Tehran, Iran (TEHRAN)	0.1349	0.2375	0.1350	0.1319	0.2343	0.1325	0.1279	0.2290	0.1289	0.1379	0.2386	0.1360
(10) Xining, China (XINING)	0.1611	0.2660	0.1564	0.1447	0.2468	0.1412	0.1496	0.2520	0.1457	0.1569	0.2602	0.1527
	Elevation Angle = 5°											
	0000			0600			1200			1800		
	MRF	Goad	Exp.	MRF	Goad	Exp.	MRF	Goad	Exp.	MRF	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	0.1046	0.1750	0.1026	0.1061	0.1766	0.1041	0.0946	0.1636	0.0933	0.0956	0.1650	0.0941
(2) Amazon Forest (AMFOR)	0.1547	0.2334	0.1571	0.1529	0.2312	0.1551	0.1532	0.2322	0.1556	0.1492	0.2286	0.1519
(3) Bangkok, Thailand (BANGK)	0.1515	0.2322	0.1531	0.1518	0.2317	0.1530	0.1509	0.2312	0.1529	0.1499	0.2301	0.1521
(4) Washington, D.C. (DC)	0.1141	0.1851	0.1122	0.1117	0.1820	0.1100	0.1106	0.1807	0.1088	0.1095	0.1790	0.1069
(5) Alaska (NAK)	0.1107	0.1799	0.1077	0.1105	0.1798	0.1078	0.1107	0.1800	0.1078	0.1109	0.1801	0.1083
(6) Northern Australia, Tanami Desert (NAUS)	0.1285	0.2045	0.1308	0.1222	0.1991	0.1249	0.1304	0.2078	0.1319	0.1365	0.2130	0.1376
(7) Pyrenee Mountains (PYRNES)	0.1153	0.1852	0.1127	0.1145	0.1851	0.1120	0.1149	0.1852	0.1123	0.1156	0.1857	0.1130
(8) Spokane, Washington (SPOK)	0.1273	0.2019	0.1261	0.1268	0.2005	0.1258	0.1245	0.1971	0.1220	0.1251	0.1978	0.1221
(9) Tehran, Iran (TEHRAN)	0.0944	0.1648	0.0938	0.0925	0.1627	0.0922	0.0899	0.1592	0.0897	0.0961	0.1655	0.0945
(10) Xining, China (XINING)	0.1112	0.1831	0.1082	0.1005	0.1706	0.0980	0.1037	0.1740	0.1010	0.1084	0.1793	0.1057
	Elevation Angle = 10°											
	0000			0600			1200			1800		
	MRF	Goad	Exp.	MRF	Goad	Exp.	MRF	Goad	Exp.	MRF	Goad	Exp.
(1) Ahaggar, Algeria (AHAGR)	0.0566	0.0950	0.0556	0.0574	0.0958	0.0564	0.0515	0.0891	0.0507	0.0520	0.0898	0.0511
(2) Amazon Forest (AMFOR)	0.0824	0.1249	0.0840	0.0815	0.1238	0.0830	0.0817	0.1243	0.0833	0.0797	0.1224	0.0813
(3) Bangkok, Thailand (BANGK)	0.0810	0.1242	0.0820	0.0810	0.1240	0.0820	0.0807	0.1237	0.0819	0.0801	0.1232	0.0815
(4) Washington, D.C. (DC)	0.0616	0.1000	0.0606	0.0604	0.0984	0.0594	0.0598	0.0978	0.0588	0.0592	0.0970	0.0578
(5) Alaska (NAK)	0.0598	0.0974	0.0582	0.0597	0.0974	0.0583	0.0598	0.0975	0.0582	0.0599	0.0975	0.0585
(6) Northern Australia, Tanami Desert (NAUS)	0.0692	0.1101	0.0704	0.0660	0.1073	0.0673	0.0701	0.1117	0.0710	0.0732	0.1144	0.0739
(7) Pyrenee Mountains (PYRNES)	0.0622	0.1001	0.0608	0.0618	0.1001	0.0605	0.0620	0.1001	0.0607	0.0623	0.1004	0.0610
(8) Spokane, Washington (SPOK)	0.0684	0.1087	0.0679	0.0681	0.1080	0.0677	0.0668	0.1062	0.0657	0.0671	0.1066	0.0658
(9) Tehran, Iran (TEHRAN)	0.0514	0.0897	0.0509	0.0505	0.0887	0.0501	0.0491	0.0869	0.0488	0.0522	0.0901	0.0513
(10) Xining, China (XINING)	0.0601	0.0991	0.0585	0.0546	0.0927	0.0532	0.0562	0.0944	0.0548	0.0586	0.0971	0.0572

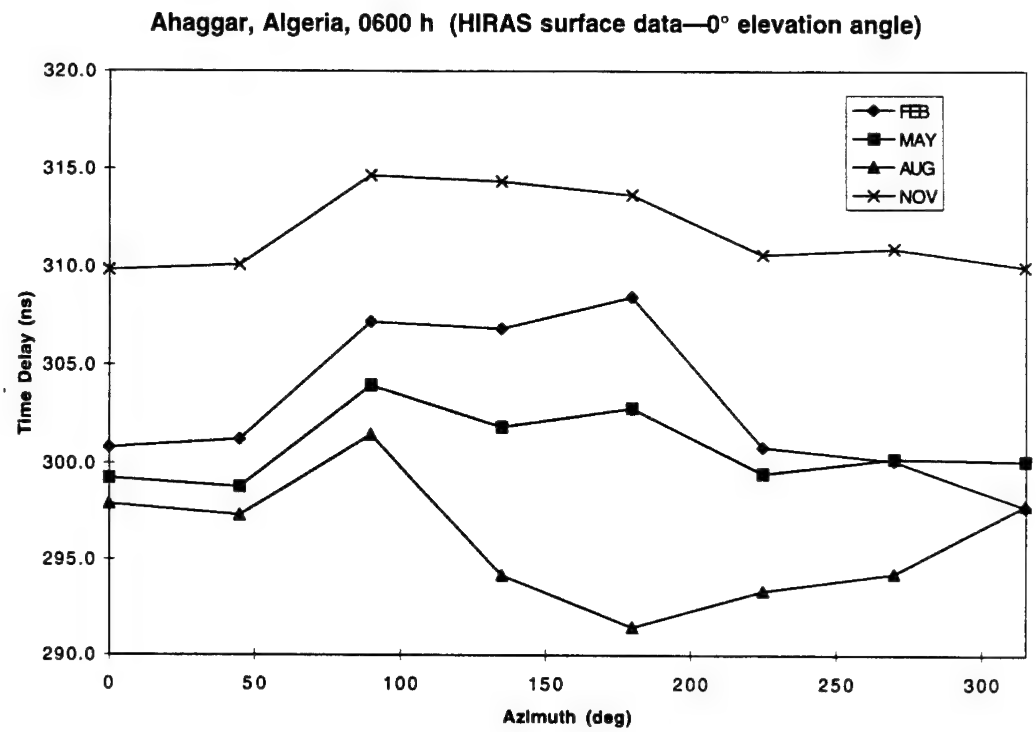
Appendix K

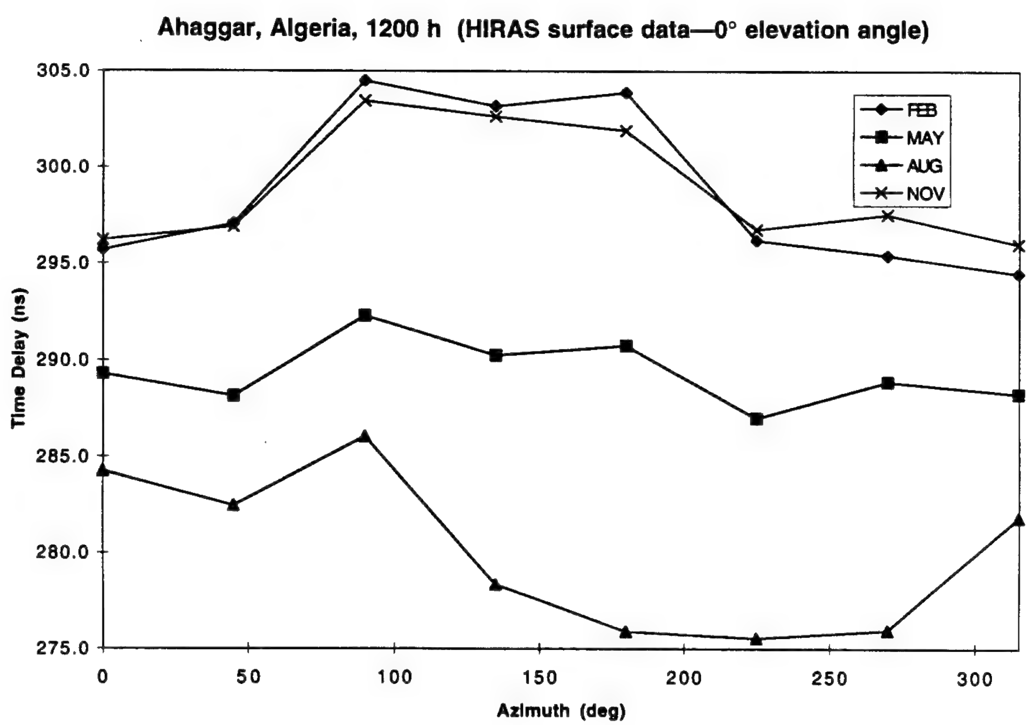
TIME DELAY VARIATIONS ON AZIMUTH BY SEASONS AND HOURS

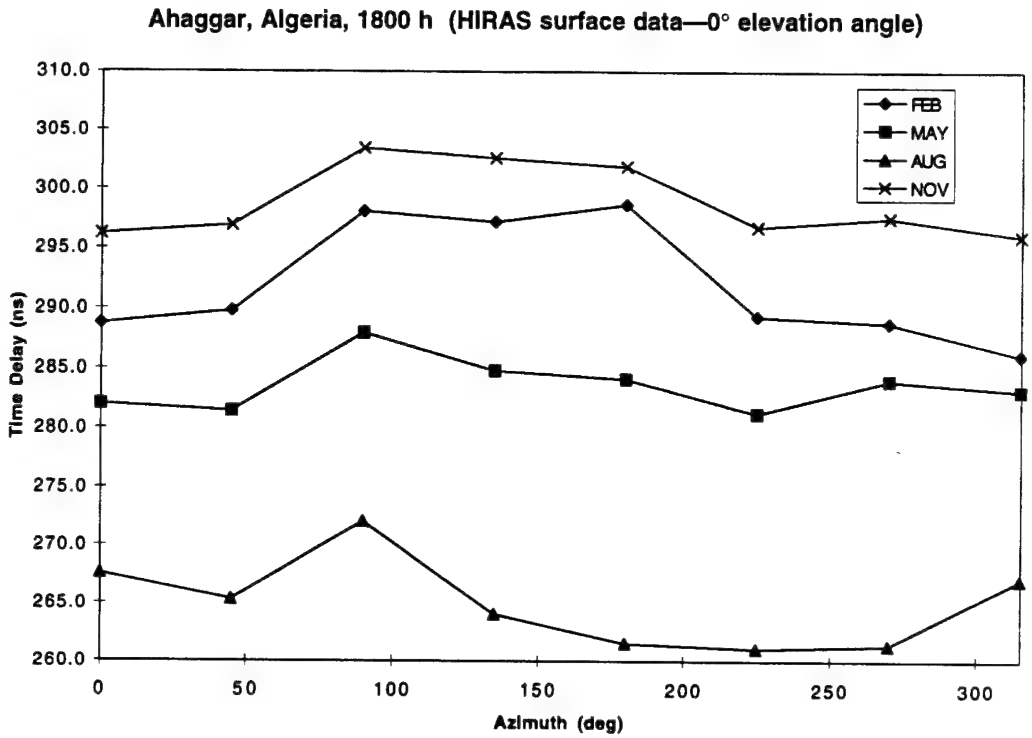
Time delays are compared by seasons and hours for azimuth ange variations from 0° to 360° in two noticeably sensitive areas—Teheran, Iran, and Ahaggar, Algeria.

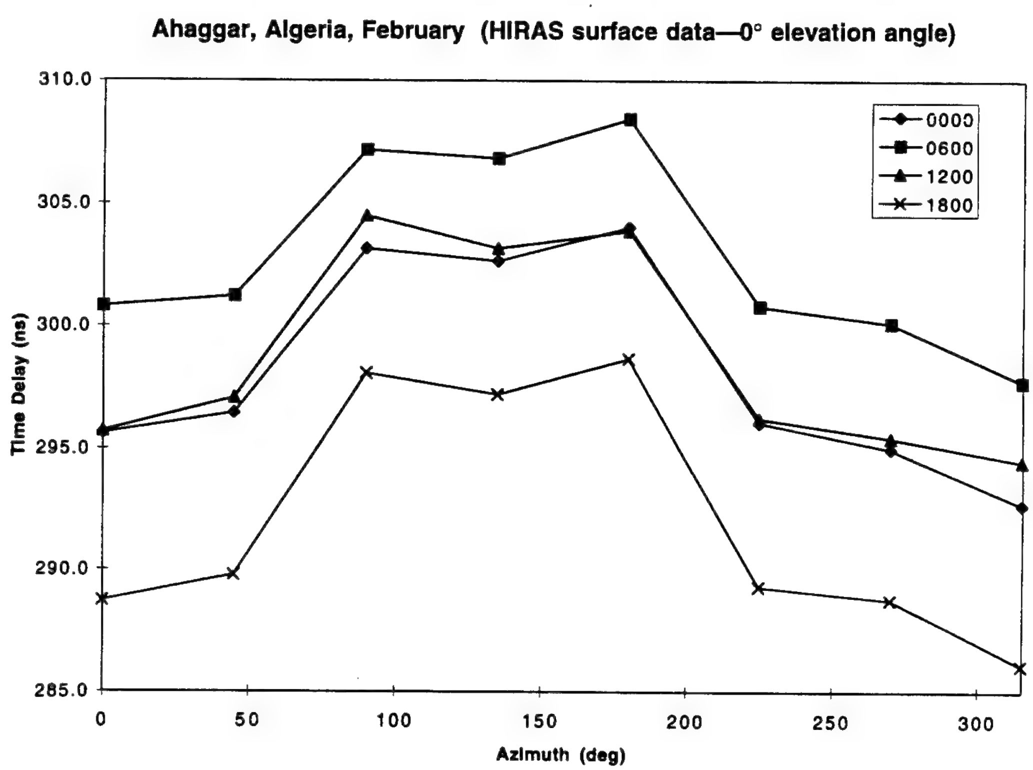

Ahaggar, Algeria, (ECM surface data—0° elevation angle)
302.0
300.0
298.0
296.0
294.0
292.0
290.0
288.0
286.0
284.0
Time Delay (ns)
0
50
100
150
200
250
300
Azimuth (deg)
FEB
MAY
AUG
NOV


Ahaggar, Algeria, 0000 h (HIRAS surface data—0° elevation angle)
310.0
305.0
300.0
295.0
290.0
285.0
280.0
Time Delay (ns)
0
50
100
150
200
250
300
Azimuth (deg)
FEB
MAY
AUG
NOV

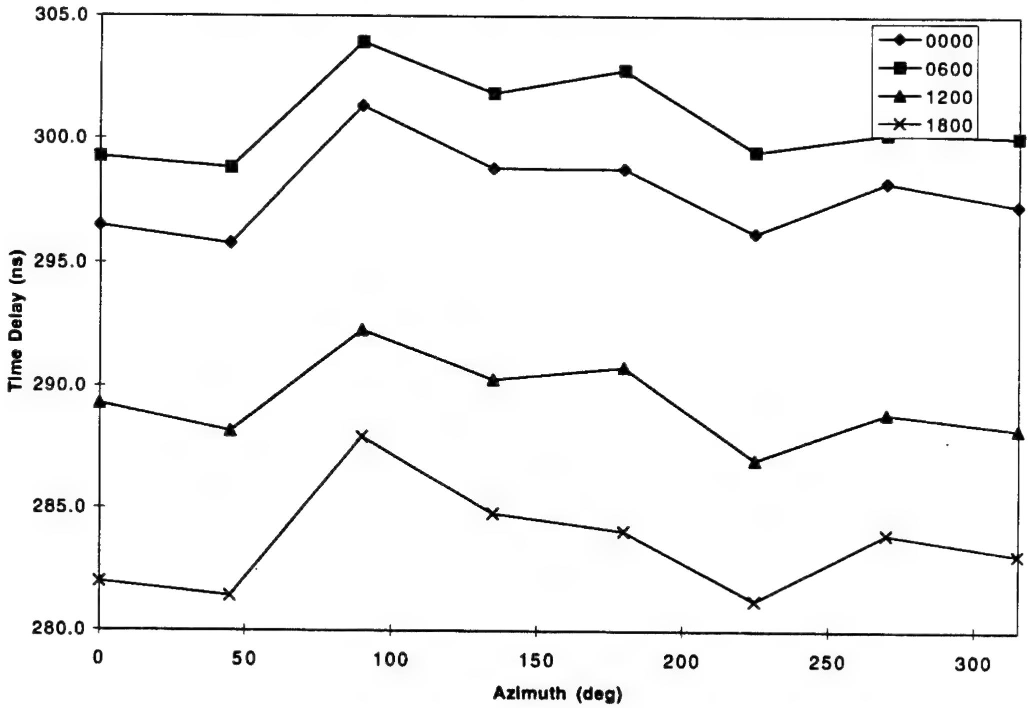

Ahaggar, Algeria, 0600 h (HIRAS surface data—0° elevation angle)
320.0
315.0
310.0
305.0
300.0
295.0
290.0
Time Delay (ns)
FEB
MAY
AUG
NOV
0
50
100
150
200
250
300
Azimuth (deg)


Ahaggar, Algeria, 1200 h (HIRAS surface data—0° elevation angle)
305.0
300.0
295.0
290.0
285.0
280.0
275.0
Time Delay (ns)
FEB
MAY
AUG
NOV
0
50
100
150
200
250
300
Azimuth (deg)

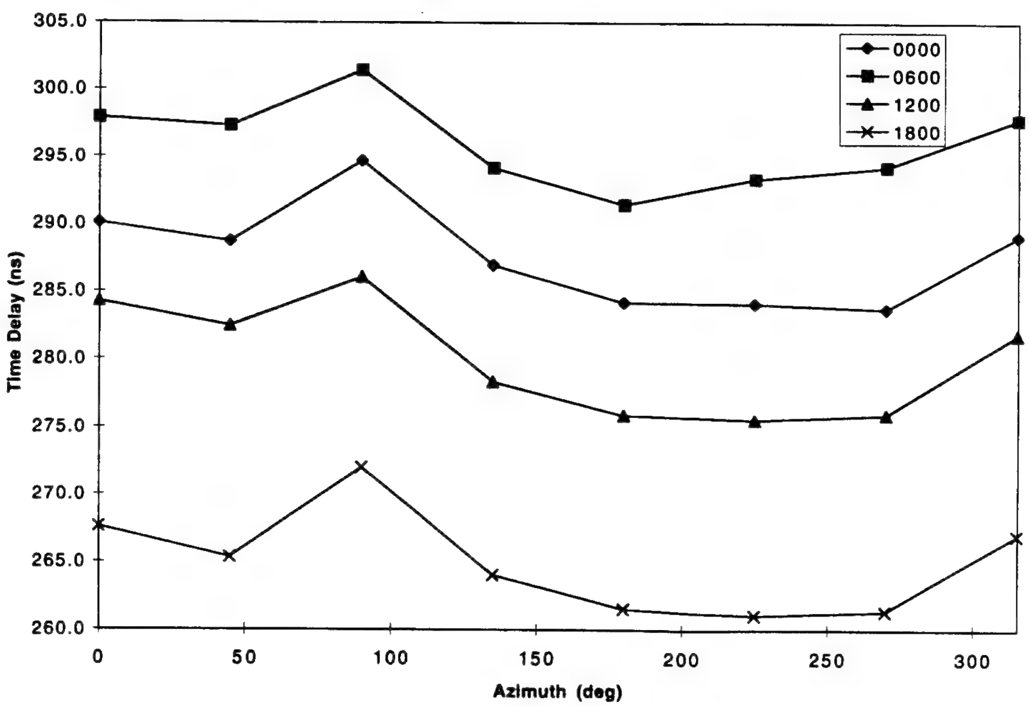

Ahaggar, Algeria, 1800 h (HIRAS surface data—0° elevation angle)
FEB
MAY
AUG
NOV
Time Delay (ns)
Azimuth (deg)
310.0
305.0
300.0
295.0
290.0
285.0
280.0
275.0
270.0
265.0
260.0
0
50
100
150
200
250
300


Ahaggar, Algeria, February (HIRAS surface data—0° elevation angle)
0000
0600
1200
1800
Time Delay (ns)
Azimuth (deg)
310.0
305.0
300.0
295.0
290.0
285.0
0
50
100
150
200
250
300

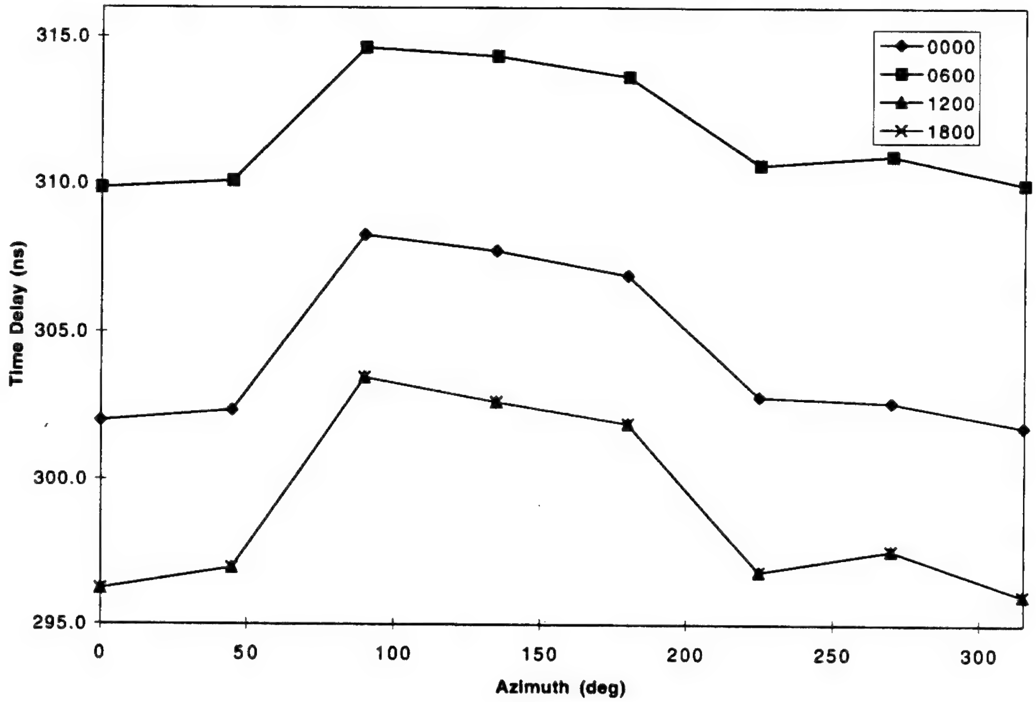
Ahaggar, Algeria, May (HIRAS surface data—0° elevation angle)



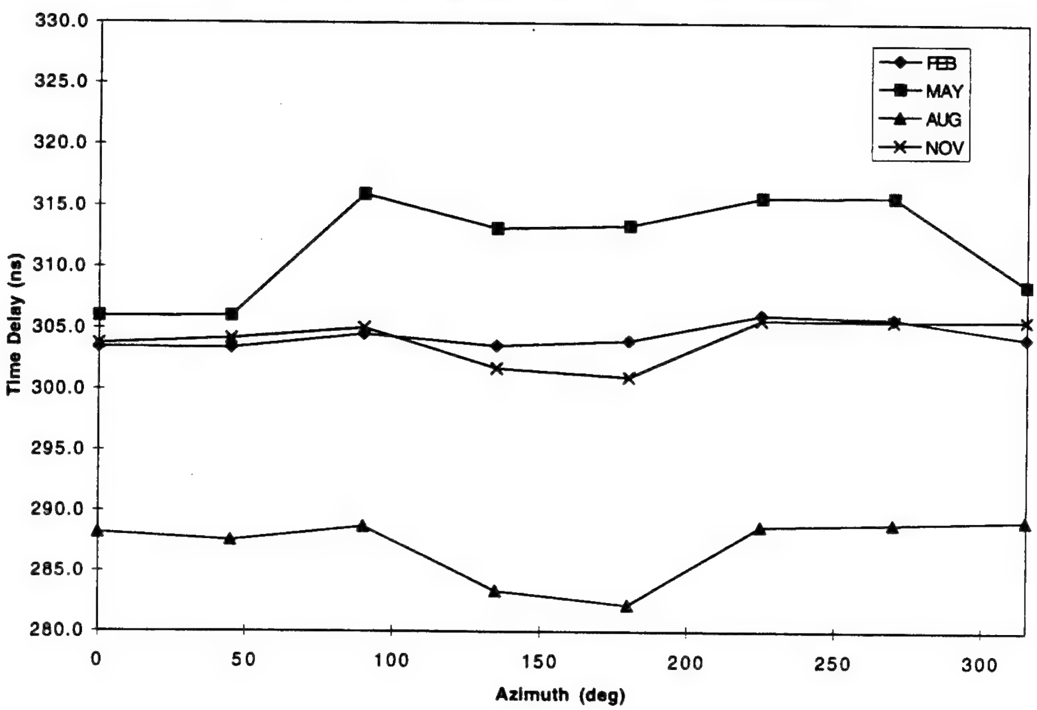
Ahaggar, Algeria, August (HIRAS surface data—0° elevation angle)



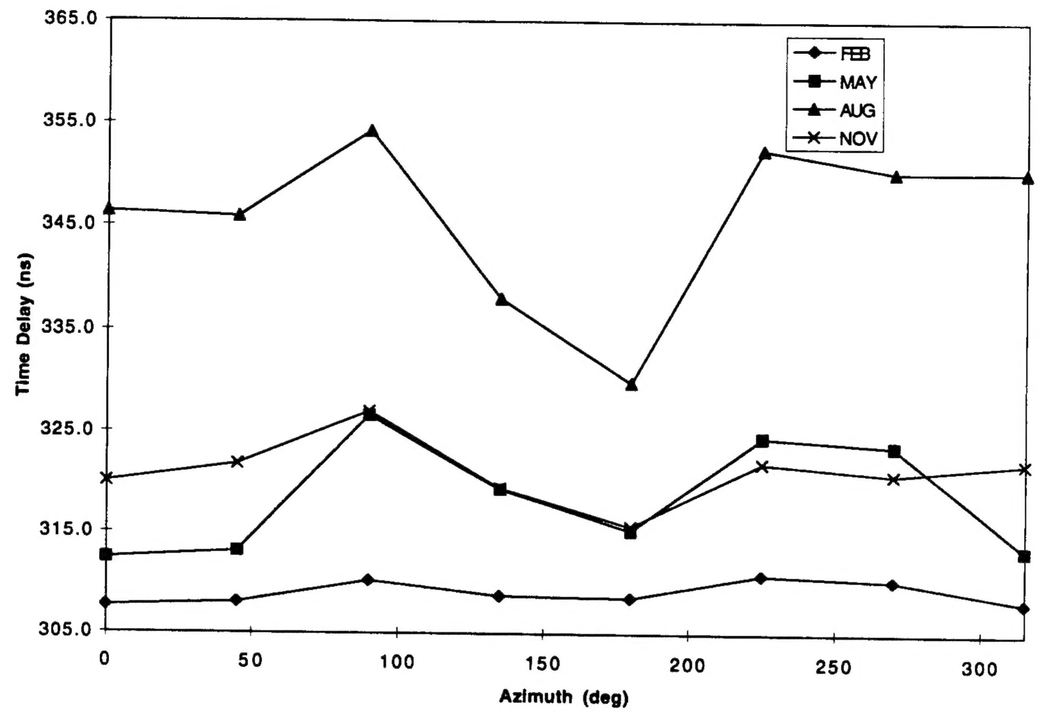
Ahaggar, Algeria, November (HIRAS surface data—0° elevation angle)



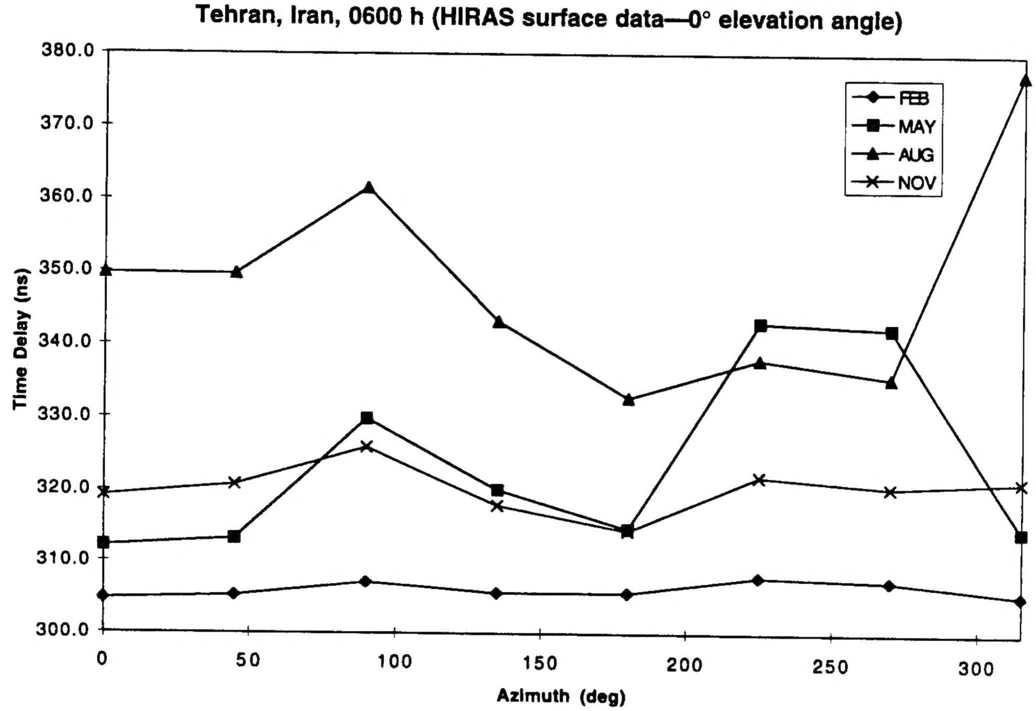
Tehran, Iran (ECM surface data—0° elevation angle)

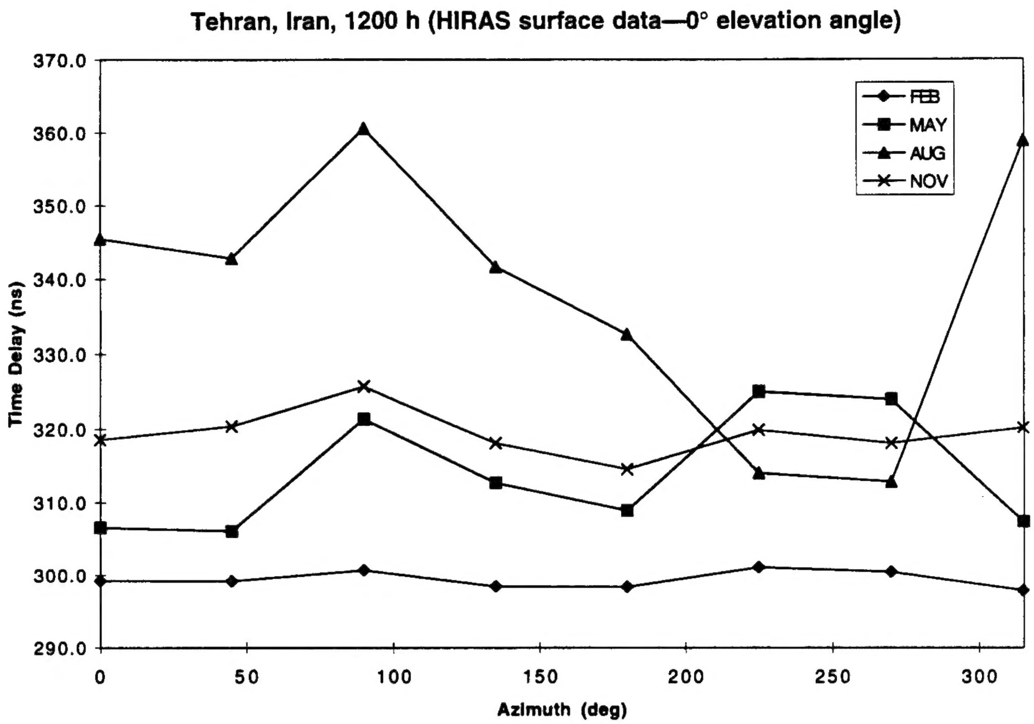


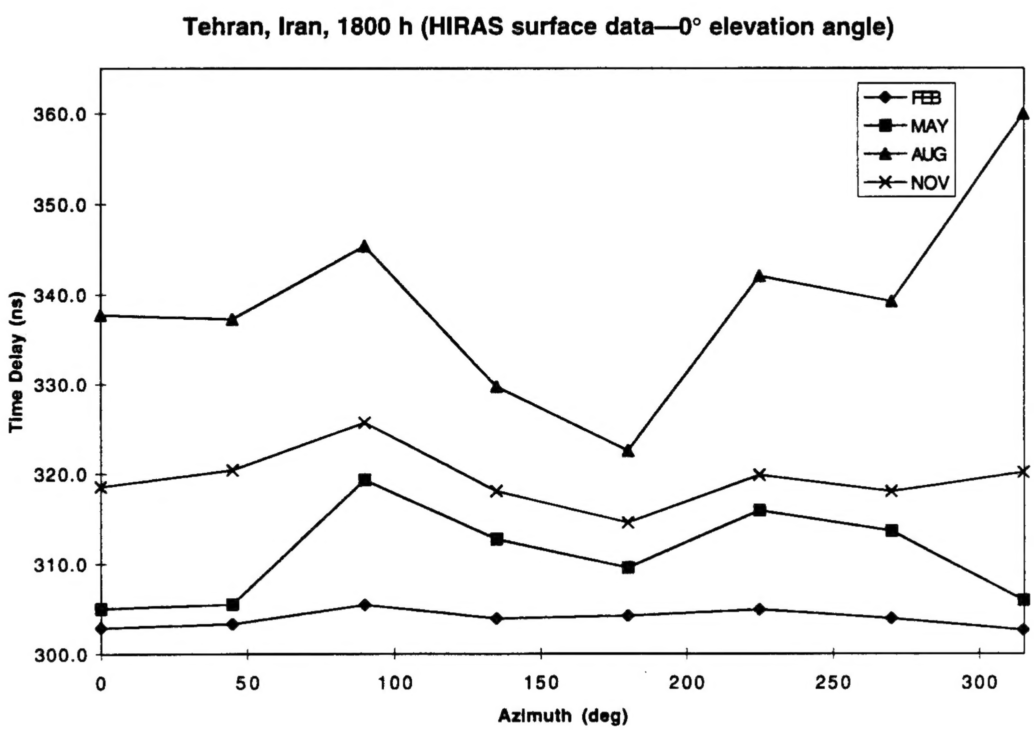
Tehran, Iran, 0000 h (HIRAS surface data—0° elevation angle)



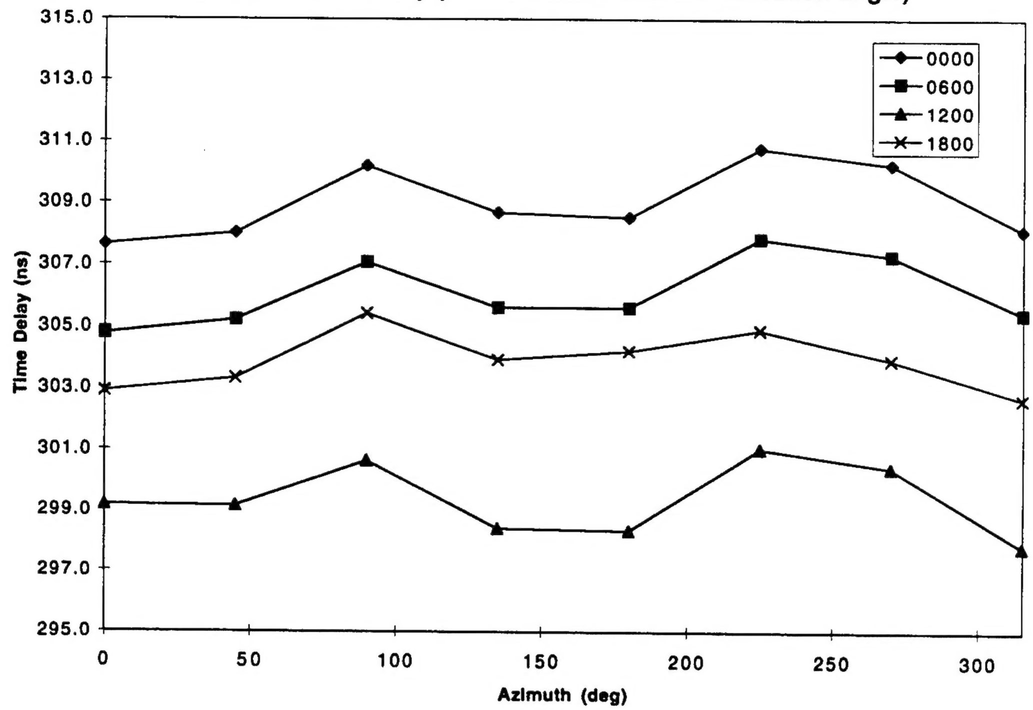
Tehran, Iran, 0600 h (HIRAS surface data—0° elevation angle)



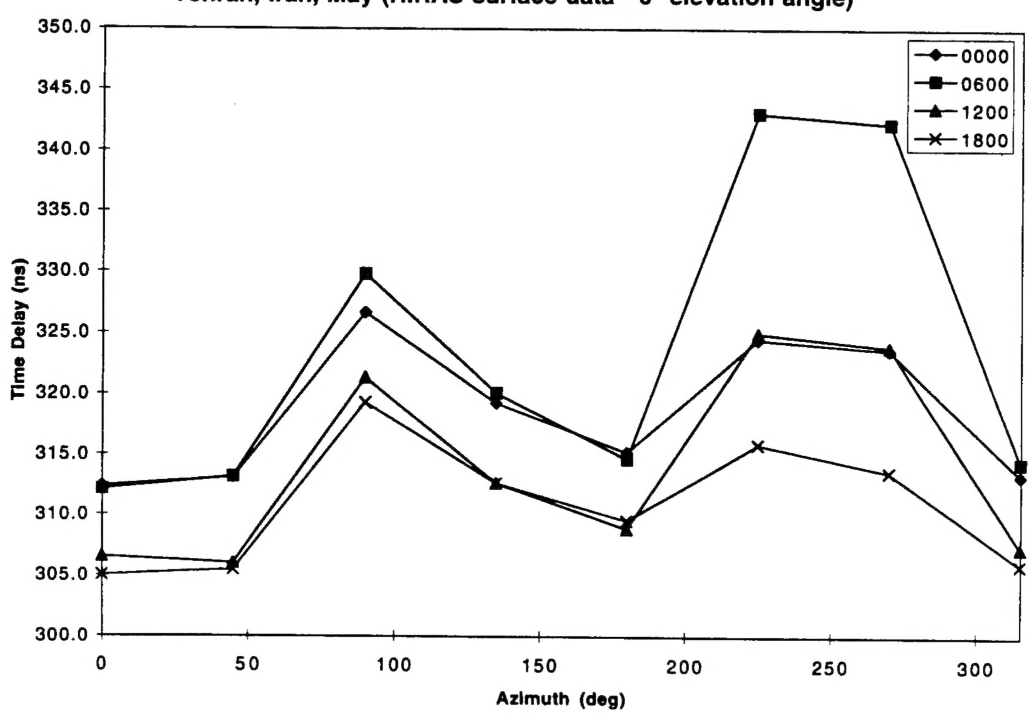

Tehran, Iran, 1200 h (HIRAS surface data—0° elevation angle)
FEB
MAY
AUG
NOV
Time Delay (ns)
370.0
360.0
350.0
340.0
330.0
320.0
310.0
300.0
290.0
0
50
100
150
200
250
300
Azimuth (deg)

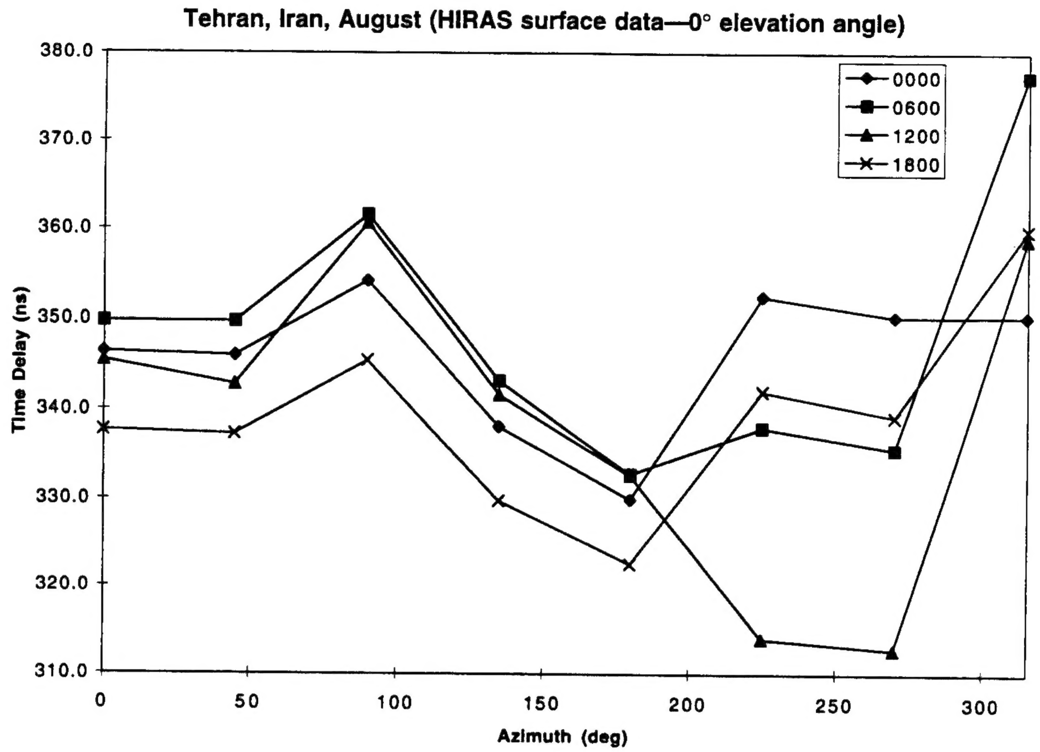

Tehran, Iran, 1800 h (HIRAS surface data—0° elevation angle)
FEB
MAY
AUG
NOV
Time Delay (ns)
360.0
350.0
340.0
330.0
320.0
310.0
300.0
0
50
100
150
200
250
300
Azimuth (deg)

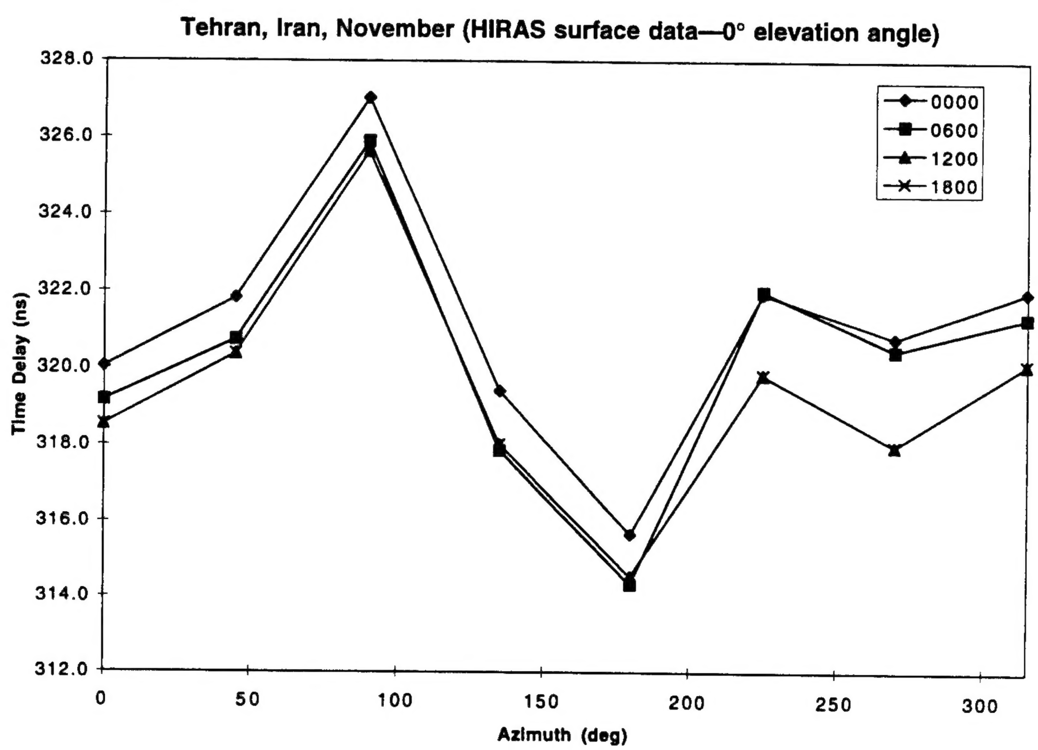
Tehran, Iran, February (HIRAS surface data—0° elevation angle)



Tehran, Iran, May (HIRAS surface data—0° elevation angle)




Tehran, Iran, August (HIRAS surface data—0° elevation angle)
380.0
370.0
360.0
350.0
340.0
330.0
320.0
310.0
Time Delay (ns)
0
50
100
150
200
250
300
Azimuth (deg)
0000
0600
1200
1800


Tehran, Iran, November (HIRAS surface data—0° elevation angle)
328.0
326.0
324.0
322.0
320.0
318.0
316.0
314.0
312.0
Time Delay (ns)
0
50
100
150
200
250
300
Azimuth (deg)
0000
0600
1200
1800